Electronic Packaging and Manufacturing.
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Lecture - 03
Introduction - III

Welcome back to the course on Electronic Packaging and Manufacturing. My name is Androop Bhattacharya and today we are going to continue on our discussion on the Introduction section. And specifically what we were going to talk about today is why is packaging so important? Why are we saying that electronic packaging is such a critical issue, is it such a critical subject and it is such a critical part in the design and manufacturing of an electronic product. So, that is the topic of our discussion today, for this half an hour: Why is packaging important?

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So, we will again just start off with what we discussed in the last class with the definition of electronic packaging and then look at the importance of this subject ok.

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So, what is electronic packaging? If you refer to the slide that I showed in the last class, is the service and art of providing a suitable environment to the electronic product as a whole to perform reliably over a period of time ok.

So, packaging does not add any functionality, but however it brings in the components or devices that perform multiple functions together on the same platform so that they can you know they can simultaneously perform their functions seamlessly with each other ok. Whether it is a CPU when and when it comes to for processing, whether it is the graphics when it comes for display, whether it is wireless, whether it is sensors, whatever it is they all come together and they talk with each other ok.

So, two things, so that is communication between the different devices or components, and then the other one is it provides the packaging, provides the electronic product with a suitable environment with a protected; with a protected environment so that it can perform reliably over a period of time. So, this is what we had discussed in the last class ok.

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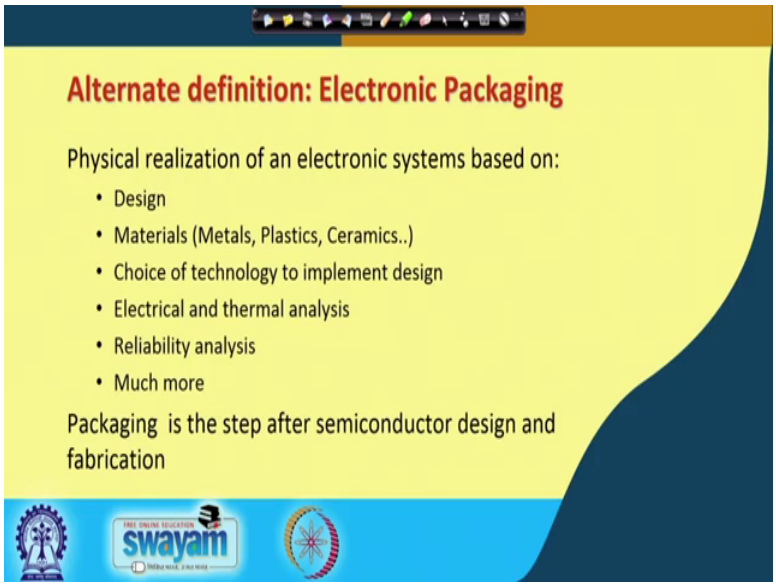

So, let us continue on that a bit more and look at an alternate definition. I mean it is the same thing that we are talking about. It is an alternate definition of electronic packaging, but it says that it is a physical realization of an electronic systems or of an electronic system based on these various things. What is the design? Materials; choice of technology to implement that designs, and where manufacturing comes into picture; electrical and thermal analysis; reliability analysis and much more ok.

So, all this comes into an into the pack design of an electronic package. So, packaging is really the step after semiconductor design and fabrication. As we repeatedly said in the last lecture it is the science and art that converts the individual components into a system that can be used by the end user giving him or her the desired user experience that is electronic packaging ok. Just to give you an analogy we all know if we if when we drive a car it is the engine which is the prime component. Engine is the one which you know which converts energy in case of an internal combustion engine, it come it converts thermal energy and then transforms or converts it into mechanical energy that drives the car ok.

But if I just give you an engine then will I have a; will the car be there? No. If I then let us say I give you the engine, I give you the power train, I give you the chassis, I give you the seats, does do you still have the car? No. They all have to come together and talk to each other and perform seamlessly so that finally one gets the driving experience ok.

And secondly, the chassis should be robust enough to protect all these systems from the environmental hazards that may come in the way of the automobile during it is operating life ok. It is the same thing for an electronic package ok so, packaging does all that. I will just; what I will do is I will just show you something which is a little bit unfortunate I would say and I just wanted to show you right from the beginning.

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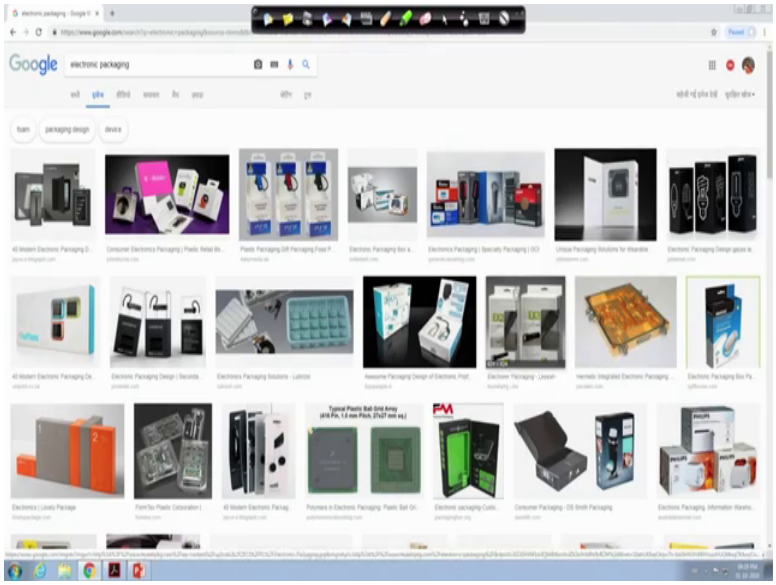

If you open up Google, let us say what I will do is I will go through this exercise with you I will open up Google search and put in electronic packaging ok. Let me do this. So, it is searching now and if I go to image see what we get these are all about packing materials, packing boxes for electronics ok. So, this is the unfortunate part it is such a such an important part of an electronic product design and yet except the people who actually work in this or practice this, the awareness of electronic packaging especially the term and what it implies is still quite low ok.

So, that was a live demonstration if you do a Google search which many a times we feel that it is a panacea and it is a solution for all our questions this is what it returns ok. So, what packaging does not mean that, we have discussed that in last class as well it is not about packing boxes. It is something much much more; much much more involved and a really multidisciplinary field of technology and science ok. So, let us move on and say that why is packaging important? What does packaging do to make it so important, all right.

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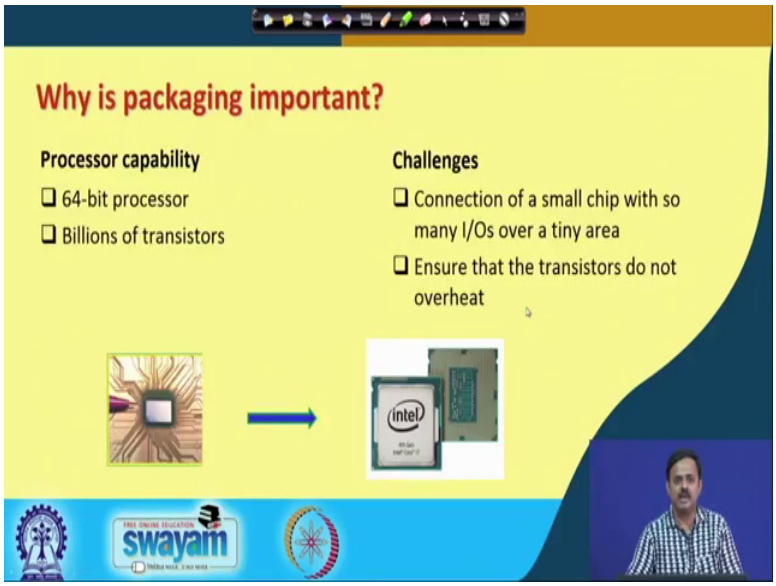

So, let us take one by one and this is a series of slides that we are going to go through now, processor capability ok. And so this is where we talk about all this VLSI design you know this modern architectures and which I mean the entire microprocessor design, whether it is for computing products, whether it is power electronics, whether it is communication devices whatever it is the processor is the main brain, which is this is a processor (Refer Time: 07:32) that has millions of transistors in a small piece of silicon and it can perform a variety of functions using the logic gates right ok. It can do a lot of functions, but once it has processed all the information it has to communicate and desist disseminate to the various components ok.

It also has to get the information from the different component different other components that is around it. So, what does it do? Now, just like our brains have our sensory organs like our eyes and ears, the microprocessor also needs all it is other components to get information and to give it out and that is what is called IO standing for input output. The word interconnect also is used to kind of imply the same thing. So, connection of a what is the challenge therefore, yes I have billions of transistors on a small piece of silicon, but then I need this silicon to talk to quote unquote to talk or communicate with the various other devices in my system.

So, this connection of a small chip with so many IOs over a tiny area, how do I do that? How do I bring out so many signals and interconnects from the CPU? One, and while

doing that while it is doing all this processing how do I ensure then the transistors do not overheat, right. So, this pictures that you see here the left one is kind of shows the piece of silicon, the right one is what is many a times called the package and if you invert the package you will be able to see a lot of these connections ok.

Here you see some pins or pads we are going to study all these in detail when we talk about interconnect technology in the 1st level of packaging, but for this one what I am trying to say is from a 1 centimeter by 1 centimeter piece of silicon you may have thousands of, hundreds and thousands of these interconnects coming out ok. That is the challenge of packaging ok.

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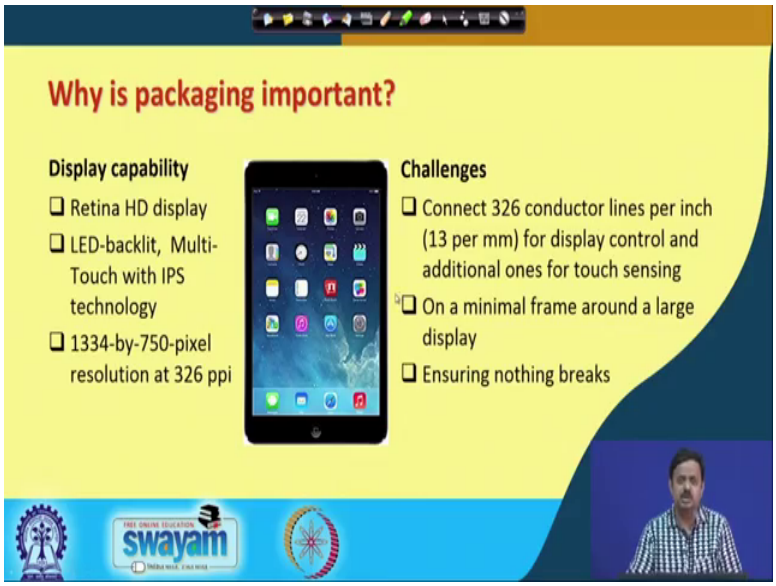

Second, this is the processor. So, to make the to make the maximum use of the processor capability ok. Display capability, yes we have display technologies that has really gone in leaps and bounds over the last few years we have retina high I mean HD display, we have led backlit display with multi touch sensing with IPs technology. We have really high definition display these days 1334 by 750 pixels now I think it is even more.

So, what is the challenge here? Yes, the display technology has gone, but when you actually have to put it in a product what are the things that you have to keep in mind? How do I connect this 326 conductor lines per inch ok? The 326 ppi resolution which is 13 semiconductor lines per millimeter that is what is required for display control and there are additional ones for touch sensing ok. It is that if it is a touch display then you

also need additional lines for sensing your touch and do all this on a minimal frame around a large display and ensure that nothing breaks ok. So, these are the challenges.

So, the display technology while it has really gone forward there are equal number of challenges in bringing it into a product and ensuring that it functions properly and reliably and is protected from any environmental hazards, clear. So, in the last slide we talk about processor capability, in this one we saw the challenges in realizing the capability of the display technology that we want to put in our product. What else.

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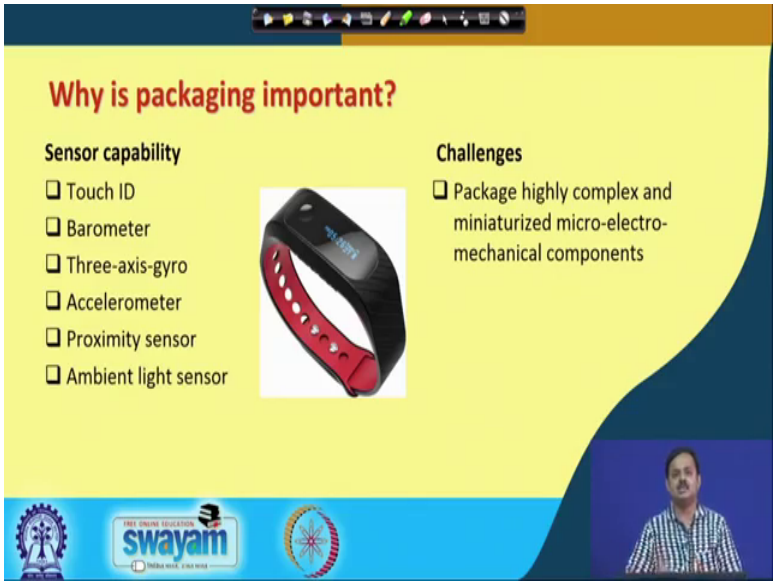

Sensor capability ok, so our modern gadgets have a lot of sensors inside, your smart phone, your smart watch, these days the exercise band a picture of which is shown here this has lots of sensors within them. There is a touch ID; there is a barometer which can which can measure the pressure ok. Three-axis-gyroscope, accelerometer, proximity sensor, light sensor to what the light sensor which what I mean by light sensor is the ambient light sensor.

So, that it senses how much light is already around you and therefore, adjusts the brightness of your screen, ok. And why is this required? That is required because to conserve energy, all right. So, these are the sensor capabilities. There are so many sensors with various high end capabilities that are there in these products. And the challenge is to package this highly complex and miniaturized micro electromechanical

components. To put all these sensors in this tiny wristband as you can see, and make them work and give you the right information by processing ok.

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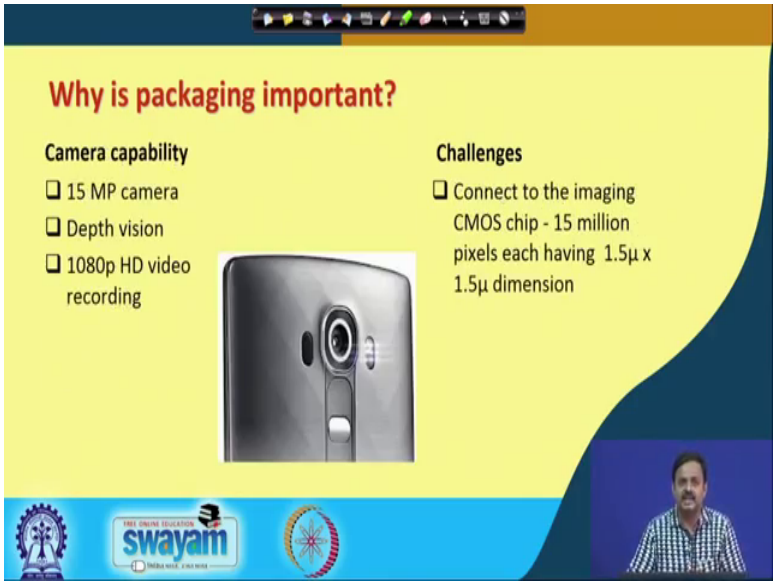

Next, camera, your tablet us and smartphones all have camera today, I mean your laptops and desktops it has camera for video conferencing, it is a front side camera ok. But we are talking about 15 megapixels camera today. My cell phone itself has 13, it is not a very high end one, but it has a 13 megapixel camera. There is depth vision ok, dual lenses giving you the 3D feel ok, 1080 pixels high definition video recording and all this goes into a small socket on the backside of your cell phone and has to communicate with the front display and to the graphics card. So, that a high definition picture or a video is recorded and stored. So, connect to the imaging CMOS chip.

What is CMOS? MOS is Metal Oxide Semiconductor with 15 million pixels each having a dimension of 1.5 microns by 1.5 microns ok. So, just appreciate the dimensions, the accuracy and the tolerances we are talking about here. We use our cell phone cameras day in and day out these days people who have smart phones, and many a times we do not realize that how much actually goes in to the design and packaging of these components in our smartphone devices or in our smartphone systems, all right what else. We talked about processing, we talked about display, we talked about sensor, we are talking about camera.

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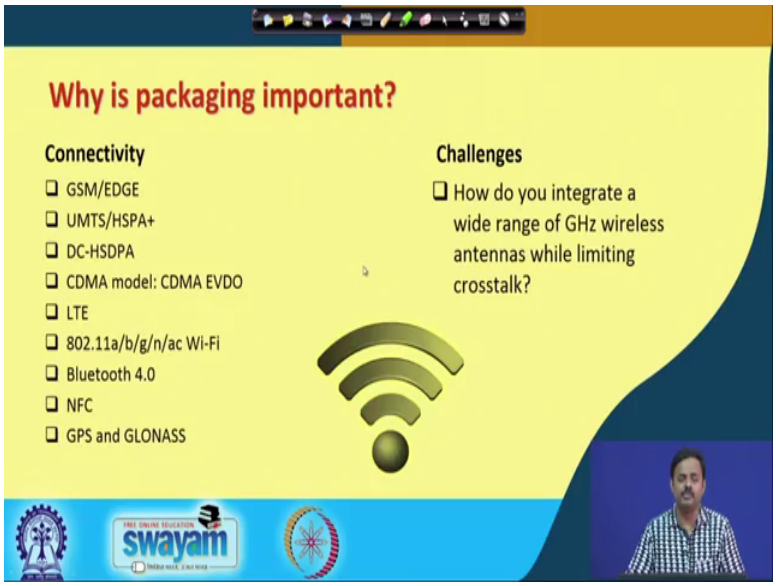

Connectivity; so connectivity it is not just about the wireless which whose icon I have shown, but everything else, right. We are, it is a world of interconnected devices we are always connected right that is what we say, either through wireless or through data plan. So, if you think about it all the especially people from the communications telecommunications background will be able to appreciate this more, you have GSM or edge, you can have CDMA and all these protocols of communication.

Then on top of that we need radio, we need Bluetooth, we need wireless and we need GPS, everything in a small device in a small product. So, the challenge is how do you integrate this wide range of gigahertz wireless antennas and still limit crosstalk. So, the integration of all of these become is critical for a packaging engineer, packaging designer and packaging engineer. Limiting crosstalk also, especially the electrical engineers who work in packaging the electrical sciences aspect of packaging deals with this.

Again if you think about it this has this is not design of a VLSI it is not design of graphics or display or sensors or you know telecommunication chips or devices or even antennas. But, it is about integrating all of them it is bringing the antennas together and seamlessly interconnecting or seamlessly connecting it to the various other device various other components in your tablet or smartphone or laptop.

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Role of a packaging engineer once again. Finally, physical dimensions look at this, this is all actually a lot of it is already packaged in the picture that I am showing, but this is everything that needs to go into your laptop, so many devices, so many components, fans for cooling, battery. How do you find place of everything and ensure that everything works reliably?

And what I have not mentioned here is it is also equally a challenge though not a technology, I mean not so much of if you think about it is not a technical challenge that way, but it is very very important that it is not just enough to fit everything, but it is also extremely important these days to have good aesthetics. Your product should be good looking; it cannot be a thick, heavy, not so good looking device. All of us want these days very sleek thin light systems ok. So, all this become the work of a packaging engineer.

So, again let us recap and see what all we discussed. We looked at the various functions of electronic packaging and what we understood is just from the feature rich point of view, just to make enable all these features and make them work in your system there are so many challenges and challenges that need to be solved by the electronic packaging design team ok.

So, all this is how all these discrete components come together and form an usable product, that is electronic packaging. And you can readily appreciate that it needs as we

discussed in the last class needs expertise from various different fields or domains of science and technology, from electrical sciences, mechanical sciences, manufacturing sciences, chemical sciences, material sciences. And under mechanical you can further you know you can further break it up into you know applied mechanics which is shock vibration and thermal which is very important because 70 percent of products fail or 70 percent of failures can be related to overheating and temperature ok. So, this is why packaging is important.

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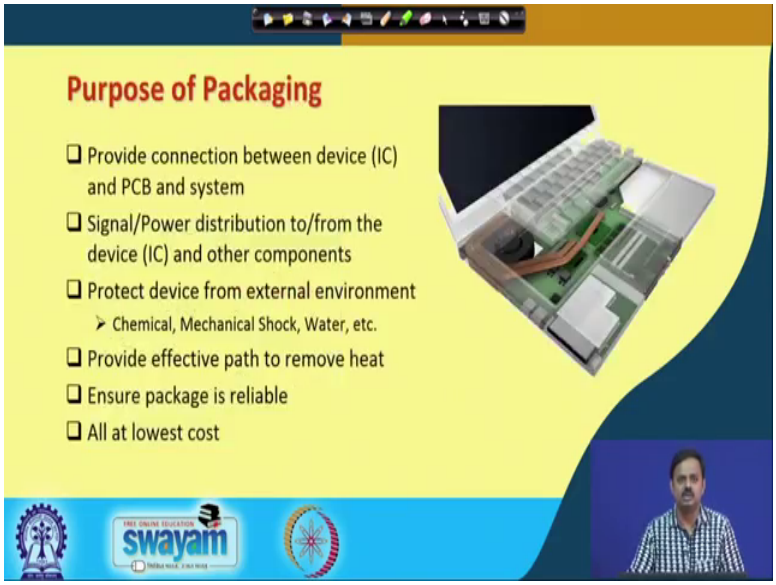

So, the purpose of packaging once more it is to provide connection between the device and PCB and system. The signal and power distribution to and from the device and other components between the different components, so this is the interconnect part ok. The communication between the different devices and what did other thing that we just talked about it is our protection. So, protect the device from is external environment whether it is a chemical or mechanical shock, water splash, humidity whatever it is and if you talk about down hole drilling or military applications, extremely harsh environments.

Let us say, in a in army tank the electronics in an army tank in the desert, extremely hot extremely hot and harsh conditions. It can be cold and harsh as well if you talk about our border at Siachen Glacier ok. Ensuring that the package is reliable and finally, very very important many a times as engineers researchers we do not pay a lot of attention, but trust me having worked in the industry finally it boils down, finally one of the most

critical components is cost. Electronics, especially consumer electronics is an extremely cost sensitive segment ok. We cannot have very expensive products, it is extremely competitive where the costs are always going down complexity is going up cost is going down ok.

So, you will not believe that, so a lot of wonderful technical ideas finally, do not make it into a commercial product primarily because of not technical reasons. They are wonderful technologies, but they probably cannot be implemented either because primarily because I would say it is cost prohibitive or implementation is the challenge integrating it or in many products serviceability is a problem. What if it goes wrong? If it cannot be serviced ok.

So, any of these you can say these are non-technical I have come up with a technology it works and it works beautifully and if you implement it is going to give you wonderful results, but still there are hundreds and thousands of some such technologies. May be way superior to the ones that we have in our products today that did not see the light at the end of the day or at the end of the tunnel because of issues related to cost or serviceability or complexity of manufacturing or implementation or assembly ok.

So, that kind of brings us or that kind of tells us the whole purpose of packaging and why it is so important ok. Again just to recap and just to you know reemphasize packaging is the science and art, a truly multidisciplinary area combining expertise from various fields that convert a piece of semiconductor into a final product that gives the user end user the user experience that he or she desires. And what are the functions of what is the purpose of packaging? You see it over here, it is listed.

And what are the challenges in packaging? And, this is fine, but if you have to package it or if you have to put all the components and package it into a product what are the different challenges. And we saw several of them in the few slides before, whether it is about you know the challenges involved in realizing the microprocessor processing capability, the sensor capability, the display capability and various other things that we discussed ok. So, we cannot overemphasize the importance of this field ok.

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So, with that what we will do is we will end today's discussion. Again with a few acknowledgments from where I have taken all this information Packaging of Electronic Systems of the Dally's book, Fundamentals of Microsystems Packaging which is the book by Professor Tummala. It has had several this is the first edition that I am talking about in 2001, but there has been subsequent editions. And finally, lecture notes the professor Chris Bailey, Chris Bailey is one of the vice presidents of IIT, electronic packaging society. He had, I had attended his microcredit course that he had delivered at our institute into early 2018 and some of the; some of the knowledge that he shared is something that I shared with you today as well ok.

So, once again with a little word of with sincere appreciation for the importance of the field of electronic packaging in you know in the development of electronic products that we use in our daily lives. And not only just in our daily lives, in even what we do not use the electronics that goes into our healthcare systems, the electronics that go to our aviation systems, the military, the down hole, drilling components, the deep sea drilling, everything I mean wherever we have power electronics in automobiles and various other systems, the telecom towers everywhere packaging plays a very very important role ok.

So, again, so from next lecture onwards what we are going to do is, we will go into the finer details and technical details of electronic packaging, starting with a few a bit of a

recap of semiconductors, especially diodes and transistors and then go directly into some fabrication technologies.

Thank you very much. And see you in the next class. Goodbye.