Electronic Packaging and Manufacturing
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Lecture - 01
Introduction – I

Greetings welcome to this new course on Electronic Packaging and Manufacturing ok. Let me first introduce myself my name is Anandaroop Bhattacharya and I am a faculty member in the Department of Mechanical Engineering at IIT Kharagpur. Today what we will do is in todays lecture in this 1st lecture we are going to start with a bit of Introduction and we are going to introduce this topic of electronic packaging and manufacturing.

Now, what do I mean by this? What is electronic packaging and manufacturing ok? So, I think this term is a little maybe a little new to many people you may have listened to my introduction video where I had spoken a bit about this course and what it is about. But, let us first try to understand what electronic packaging is and that is what we are going to do in this 1st lecture that we are going to discuss today.

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So, without further a due the concepts that we are going to cover today are as follows. We will start with a little bit of information about the electronics industry today as we all know that electronics is very very what should is very omnipresent in our life's today.

And we are going to talk about that what are the different kinds of electronic products that we come across in this world and where we see electronics in the various fields, various areas, various domains in our everyday life.

Followed by that we are going to talk about electronic packaging, what is electronic packaging ok? So, this is probably going to answer at least partially the 1st question about what are we what do we mean what is the main crux of the course that we are going to discuss ok? Thereafter we are going to talk about the different levels of packaging. So, I am going to just introduce the different levels of packaging what is 1st level of packaging, what is 2nd level of packaging and so on and so forth. But, primarily in the next course of on the next many lectures in our course we are going to take each of these levels of packaging one by one and study them in detail.

Now, what are those details that we are going to talk about when we introduce you where when I introduce you to the different levels of packaging. And finally, what we will do as part of this introduction module is to start with the very basic first level which is called the wafer from where we get the silicon dyes that go into our microelectronic devices ok. So, that is going to be the concepts so, the topics that are going to be covered as part of this introduction module ok.

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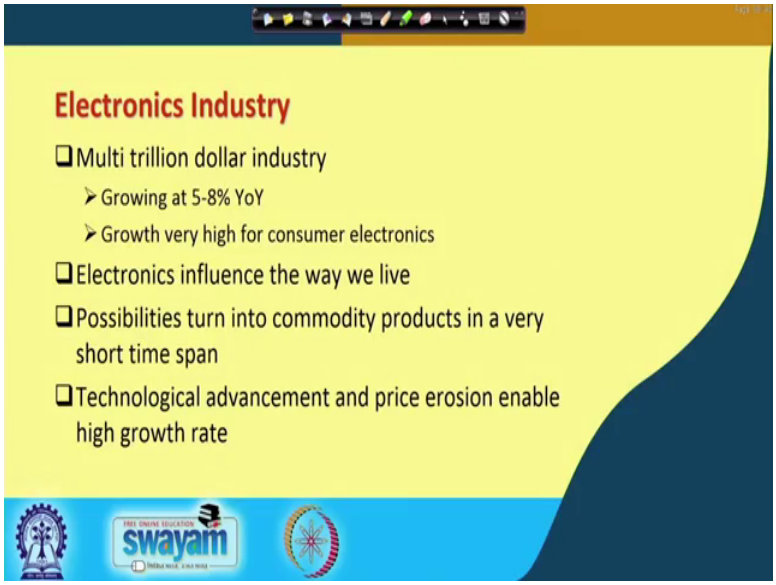

So, let us move on and try to look at electronics industry. So, my friends I hope you will all agree with me that today our life has been invaded by various electronic products ok.

We all probably all of us own a mobile phone today it is our constant companion and that is probably of the most omnipresent, the most ubiquitous electronic product that we use in our lives ok. And definitely a little bit advanced form of a mobile phone is a smart phone which also many of us have today and there the smart phone is not just a phone anymore as you all know it has become our watch, it has become our camera, it has become our you know the a device where we can listen to music, watch movies, we can record music and so on and so forth right.

So, as we can see that the electronics industry on the whole is slowly or not slowly over the past few decades has grown at a very rapid pace and it is growing still growing at 5 to 8 percent year on year; if you look at the entire electronics industry that is ok. Now, out of that if you look at consumer electronics which is where our smart phones, our laptops, our computers, tablets or even if you talk about televisions and microwave ovens and radios where these come in to pick the music players. So, these are all part of consumer electronics.

So, out of electronics this consumer electronics segment grows at a much faster rate and again we can just think about that using the example of phones. Let us say when I was growing up for example, may be 30 years back a family would have one landline phone many families did not even have that. And today if you look at it is not anymore that one family has one mobile phone it is like every family member every adult family member has one mobile phone. So, that is the pace at which if we just talk about the phones that is the pace at which it has grown or it has been growing.

So, mobile phones is one example TV's ok, I still remember in my childhood in the entire locality very few houses would have a very few families used to own a television ok. I myself used to go to a neighbors place to watch television when there was a good football match or a cricket match maybe the quiz show that used to come in the Doordarshan channel at that time. And then slowly 1 day my family when I was probably in the 6th standard or 5th standard my family owned the 1st TV today, it is hard to find especially in the middle class or even up forget upper middle class.

Even in middle class Indian families I think it is very rare that a family does not own a television they may not be watching it for example, I hardly watch TV these days except

for sports and sometimes news, but I own a TV. Anybody who starts who sets up his house TV has become an essential commodity same for music player right.

So, this is the pace at which the electronics industry has really grown and I am again talking about consumer electronics and you think about laptops and desktops I mean again every family these days. Especially, if you have school going children going to high school or college and all of them need a laptop today. I am just talking about you know just end users as in the as in as in people not even enterprises or colleges ok. So, that is the pace at which electronics industry as a whole is growing at particularly consumer electronics industry is growing.

So, electronics is influencing the way we live right you think about if you just take a few seconds and think about a regular day in your life and go through the sequence of events you will appreciate that how much electronic products have invaded our lives and how much we have become dependent on it and why is this. So, why has electronics become so important? This is because the possibilities of turning or possibilities of translating the theory of microelectronics into an usable product that is enormous. And people are trying out newer and newer technologies every day different variants of electronic products smart watches for example, I mean that is that is probably a product that came maybe 5 6 years back and today you see that it has kind of you find I do not know 100's or maybe 1000's of variants in the market today ok.

All with a little bit of different features maybe most of them are very similar to each other, but a little bit of uniqueness in each of them ok. And you can develop these products in a very short time span, you come up with an idea you go to the lab you try out and then you and if it works if the concept works you convert it to a product which is usable and then you market it ok.

Compare that with an automobile, compare that with a healthcare product which also by the way all of these have electronics today. But, if you compare these let us say a CT machine a new magnetic resonance imaging machine in the healthcare industry or a new automobile you see that the design phase itself is probably 4 to 5 to 6 years and the lifespan also is much larger ok. And the other thing that we need to take a taking into account is the very fast pace with which technology has grown. In electronics we talk about feature size in nanometers the way it has grown and the way the miniaturization

has happened it is unbelievable and probably unmatched in any other sector that we can think of.

Maybe material science is another one if I think about the last century, but other than that it is electronics and hardware ok. And as a result what has happened is these components the electronic components have also become very cheap, if you compare prices of an electronic product 10 years back versus it is today you will see that most of the products of equivalent features have become cheaper that is not true for most industries by the way right and most of the other things.

A car for example, it the price goes up, but if you think of a TV for the same features the price goes down for a cell phone the price goes down. So, this is the uniqueness of electronics industry and that is what I have captured in this in these bullet points and what I just described. It is a multi trillion dollar industry today multi trillion dollars think about that 10 to the power 9. And still growing at 5 to 8 percent year on year it has really influenced our life in a big way as I was talking about we are talking about a few products.

And this is possible because if you think come up with an idea the possibility of turning into a commodity product in a very short time span is large ok. The lifecycle from the concept to a final product the design cycle is very very short. And finally, the technological advancement and price erosion has enabled very high growth rate. So, this is electronics industry and therefore, what I am trying to the key message I am trying to deliver through this slide is the importance of electronic products and commodities in our lives today and therefore, why is it important or why the subject area of this course is so, important alright. If that is clear now and if we, if you all appreciate the points that I have mentioned in this slide with your kind permission I will move on to the next one.

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So, what are the features of an electronic industry? It is a technology driven business; look in an electronic product if you are not working on the cutting edge, if you are not talking about innovation your product is going to go obsolete in no time ok. And we have seen several examples of that in the last few years in the last decade itself there is a continuous price erosion you have to be competitive. If you come up with an absolutely new product yes you can probably charge a premium, but again your competitors are going to catch up.

And so, you cannot maintain that high price for a very long time and that is where the need for innovation and coming up with the next new product becomes. So, important, but if you can do that it is a high growth rate, if you think of a product that comes to the market and it becomes successful the growth rate is just huge. Because, again one of them is the price comes down and second is the desirability increase if it is a really good product right my neighbor my friend has an iPhone I also need to have that, that desirability comes and that gives rise to a high growth rate.

Sometimes my you know my parents and uncles they ask why does everybody in the family need a cell phone what is there is to talk about so much. Because, they are coming from a generation where just one landline phone was sufficient for the family that itself as a luxury right do we need it that is a different story I would say yes, I need it somebody else will say not really, but everybody is having a so, I should also have it ok.

But, whatever it is whatever be the reason we need ways we desirability based the growth rates in successful electronic products are very very high right.

So, there are large volumes in global markets and short life cycles now why is this important short life cycles this has two things one is of course, it is about the growth rate we normally do not use it we normally do not use an consumer electronics product for a very long time. I know people who change their phones every year I think average I would say most people change their phones every 3 to 5 years today do they really need to change may or may not I mean probably it is not so, critical, but they do change alright.

TV's yeah maybe that lifespan is slightly more, but still not very long ok. So, the life cycles are very short for most consumer electronics. If you think of electronics that go to your aircraft engine that go to your spacecrafts that goes into your oil drilling we are going to talk about all those. So, those are definitely going to be designed for much longer lifespan's ok. Now, why is this important and this because then it gives the designer or designer has to make a judgment that what is going to be the typical life cycle of my product and therefore, I am going to design a product. So, that it can survive for that expected lifespan trust me nobody designs a cell phone today to last for 20 years that is an over design that is if you want a cell phone to perform reliably over 20 years that is an overkill.

It will lead to added cost it will lead to added complexity newer materials more what should I say more degradation proof designs and features is that required proper probably not. So therefore, the life cycles of individual electronic products is very important not just to drive the market growth and price, but also from the designers point of view as to water how much how reliable should my design be.

So, we are going to again talk about this in more details when we talk about reliability the reliability section in our in our course which we will come towards for the second half of the course ok. So, what I am showing over here is a mobile phone a very sleek nice modern mobile phone and what goes inside ok. It is a nice usable product a very good looking product aesthetic product that we buy, but was what goes inside are these different components on a motherboard and which is what you see here. So, this is what we are going to talk about more in more and more details when we talk about electronic

packaging. We are still not talked about what is electronic packaging still hold on we will come to that I am building the suspense all right.

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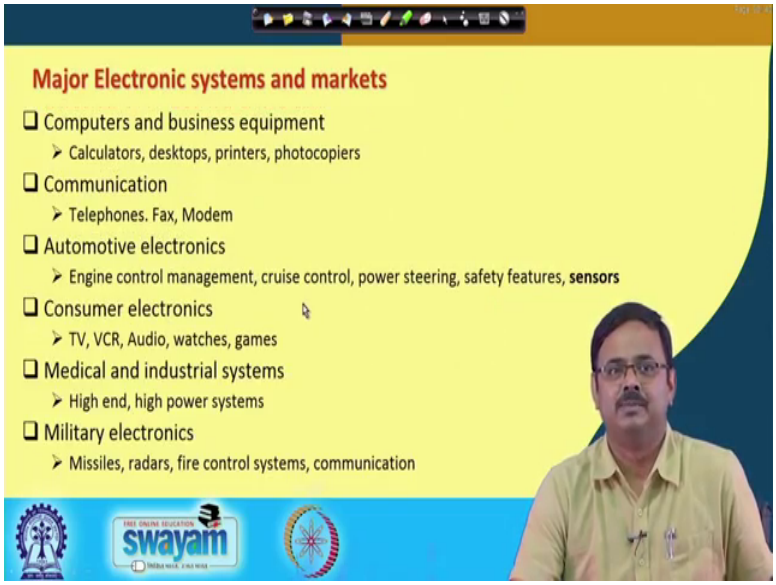

So, let us move on to the next slide and still appreciate about the presence of electronics in our lives major electronic systems and markets computers and business equipment calculators I believe calculators have now become well there are still scientific calculators that that our students use here thats the only thing they can bring to the I mean they can bring to the exam hall. But, you know if you ask me I do have a calculator by hardly use that if I have to do some calculations I just take my phone out and do it there using that app, but I would still I still included calculators because still a sizable population use calculators.

Desktops printers, photocopiers, laptops these are all under computers and business equipments ok. If you think about communication we are talking about telephones we are talking about fax machines modem networking switches these are all under communications these are electronic products that come under the communication sector clear. So, we talked about computers computing platforms we talked about telecom automotive electronics. You will be surprised at how much of electronics is there in an automobile there are 1000's of sensors in an automobile your temperature sensor, your fuel sensor, your rpm meter these are all electronic devices today ok. And now when we are talking about electric vehicles or hybrid electric vehicles a large component of that is

power electronics we are talking about batteries in hybrid electric vehicles and electric vehicles plug in electric vehicles electric vehicles batteries. And along with the batteries comes a battery management center battery management system BMS these are all electronics and that goes into the automotive sector imagine go back 30 years or so, go back to the times of ambassadors and fiats there was not too much of electronics in our cars in those days. But, today there is electronics everywhere power steering power windows remote locking everything is electronics today ok.

Consumer electronics this is where you know the digital home segment comes into picture TV's, CD players, VCR's audio players, watches, games, the Xbox, the Nintendo's these are all part of consumer electronics computers by they are also part of consumer electronics. Computers as in the desktops laptops tablets there all part of consumer electronics ok. Medical and industrial systems you may not be using it every day but if you go to a hospital, if you go to a hospital the flat blade X-ray the ultrasound the MRI, the CT scanner there are there is a lot of electronics in each of these systems.

Not just the way they function, but on the back end the imaging part when you get the result the images from your CT scan or MRI scan there is a lot of imaging that goes on image processing using computers computing power micro processes ok. The ultrasound handheld probe that the doctor uses has lot of electronics both in that probe itself as well as in the station the base station that we call it which is connected with the wire. And today actually we are going towards wireless probe as well which actually moves a lot of the electrons from the base station to the handheld device of the ultrasound scanner industrial systems.

So, this is the age where today the most hot topics is industrial automation industry 4.0 when you automate there is a lot of electronics that you need to have because primarily driven by sensors and feedback control ok. Military electronics very very important field these are electronic products that are supposed to survive and operate in what we call very harsh environments it is in a war zone outdoor applications missiles radars fire control systems.

Communications during in the military the communication systems the satellite phones these are example the military electronics are examples of high end electronics which operate at very harsh conditions there is a whole segment in electronics that we call

design of electronics for hot and harsh environments. Along with that along with military you can also think of aviation both military aviation as well as civil aviation our aeroplanes have lot of electronics. I think most of them the controls are all about electronics right and what else yeah deep sea drilling deep sea or even terrestrial drilling when we are trying to extract oil or natural gas you we not imagine how much of research on electronic products and sensors.

And reliable operation of such electronic products under those down hole conditions or deep sea conditions how important they are under water conditions ok. So, look at this gamut of domains where electronics have become so important starting right from computers consumer electronics to communication to automobiles to medical devices to aviation systems to army or military systems. This is some of the mean examples right.

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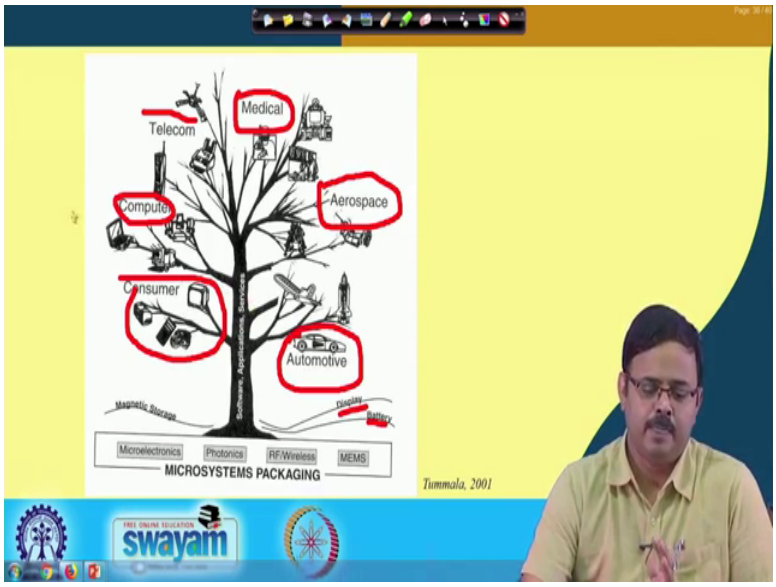

So, that is what is shown in this nicely over here this is from a picture from the book by Professor Rao Tummala it is called Microelectronics Packaging and you see the different if I come here and try to point over here sorry. So, look at some of these telecom we talked about, medical we spoke about aerospace that is what aviation we were talking about automotive, consumers, computers think about it. Other than that storage magnetic storage display batteries and along with all that of course, this is a tree this is an ecosystem. Today we are talking about internet of things right where every device communicates with each other there is a lot of data sharing and along with that comes of

course, very importantly security of the data. But, when you talk about this IOT revolution that is going on today where we are talking we are becoming. So, important on not just electronic products, but also the way these products can communicate and exchange information with each other this understanding this entire ecosystem becomes very very important ok.

And so, central to that is what you see here is a communication if this is this ecosystem is represented by this tree the communication happens because through the softwares applications and services. So, along with this growth in the electronic sector the hardware sector there is also a demand or this has also led or side by side there is a complementary growth or demand for better software better services better networking so on and so forth ok. So, we are still talking about electronics segment on the whole and trying to appreciate how important and how omnipresent it has become in our lives today ok. So, let us move on and try to see in the next phase.

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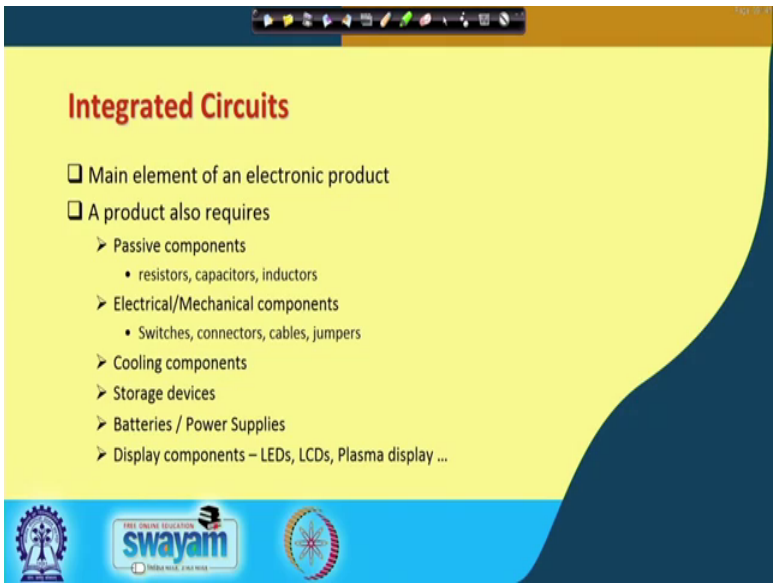

Now, if you talk about an electronic product central to that it is functioning it has got some features, it has got some expected functions a laptop is supposed to do some functions the MRI machine in the hospital is supposed to do something it is supposed to capture images ok. So, the main so, what is the main product the what is or what is the main component: what is the brain of each of these electronic products and there that is

where the most important component in the electronic system or device or product is the microchip or the microelectronic chip that has got integrated circuits inside.

Is the typically made of silicon that is still the most common and most popular element of which electronic device or microelectronic integrated circuits are made and inside the silicon when we talk about integrated circuits we are talking about the various transistors and diodes and this and that and all of these other things are ok. So, these are the various features that goes into a silicon microchip ok. So, again one thing I want to just mention at this point microprocessor microchip chip semiconductor these are all going to be these terms are going to be probably used a lot in this course and used interchangeably that die ok.

So, die microchip IC the semiconductor these are all going to be used interchangeably. So, I will try to spell them out as much as possible, but in some case if you if I am using them parallelly or I am using these different terms rest assured that or please be assured that unless otherwise stated they all mean this silicon device with integrated circuits inside alright.

So, main element in electronic product is the microchip with the integrated circuit ok, but along with that integrated circuit which is a piece of silicon with transistors primarily inside you have memory on chip memory and so on and so on and so forth. You also need many other components in that system ok. There are mechanical components as well switches, connectors, cables jumpers we are all going to these are all form part of packaging we are going to talk about them. They are cooling components because your product has to operate within a maximum allowable temperature.

So, the heat has to be dissipated, there are storage devices you know about hard disks you know about solid state memory that is over there in our electronic products especially the computing platforms. Batteries and power supplies are required especially in mobile or handheld products and display components ok. These are some of the examples I mean this is not an exhaustive list, but what I am trying to say is apart from the integrated circuit where a lot of research goes on the VLSI design the very large scale integration the architecture that what is called the micro circuit architecture or microelectronic architecture that gets into that goes into your micro electronic device; an

electronic product the final product the usable product that we use also has a variety of other components present inside ok.

And all these have to work in perfect harmony to make give a good user experience to the final user ok. So, that is where what we will we will end today this introductory lecture we are going to end here today. And, in the next class we are going to pick up from here and talk about what is packaging, what does electronic packaging actually mean and what does it entail ok.

So, thank you very much and I will see you in the next lecture good bye.