An Introduction to Electronics Systems Packaging

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Module No. # 01
Lecture No. # 03
Products and levels of packaging

Welcome back to this course on electronic systems packaging. This is the third lecture in this particular course. I hope you have reviewed the two hours of this series.

In the first one, I have given a brief introduction to the objectives of this course, what this course will aim at and what the viewer or a student will benefit from. Secondly, I have started the introduction to systems packaging and we have seen various topics during the last hour. What I will now do is, give you a recap of the last two lectures, so that you are on page with my lecture series.

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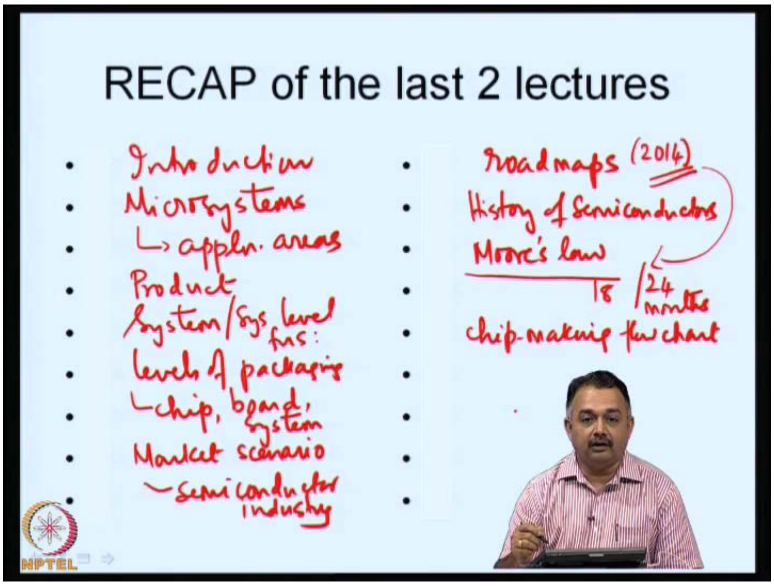

The first one is, we have seen introduction; the second one, we have seen the term called microsystems. I am introducing this term called microsystems, because many products today come under this classification. We have seen under this, various application areas. We have seen system configurations in the field of automobiles, consumer electronics, communications, military and so on. Then we have seen or defined briefly what a product is. We have also seen what a system means. In today's context, using the term system becomes very important; because if you want to define a product, you have to define system functions.

So, any design today, in electronics packaging, should be viewed at system level functions. We have seen system level functions.

Then, we have briefly seen the levels of packaging. We have seen terms like chip level packaging; we have seen the term called board level packaging and system level packaging and what it means. Of course, we are going to see these terms in much detail.

Then we have seen market scenario. We have seen globally, the impact of packaging on the economic growth of individual countries and market share in various application areas.

We have also seen the growth of semiconductor industry, because if you talk about packages and packaging, the starting point is your device, chip or a bare die; how the die is going to be packaged. So, we need to be on page with the semiconductor industry today and in that context we have seen roadmaps. I have been stressing this that roadmaps are very essential today to understand the growth of semiconductor industry.

We have seen the history of semiconductors. We have seen various processes over the last few decades and we have also seen the impact of materials, processes and the direct impact on the evolution of systems. We have also seen a very important factor that dictates the roadmap, that also influences the growth of industries and that is known as the Moore's law. I hope you can recollect what Moore's law is, which briefly states that the number of transistors built on a die doubles every eighteen months. But, I have also mentioned that in today's context, actually the growth is around twenty four months.

But Moore's law is still valid today. We have seen that and the roadmap of International Technology Roadmap for Semiconductors and other industries up to 2014, which I have shown in the last class, is a direct indication of the validity of Moore's law. Then, we briefly talked about the chip making process and the chip-making flow chart. Of course, I mentioned to you that we are going to look at the detailed process flow of how a chip is made. So these are some of the things that we have seen in the last class.

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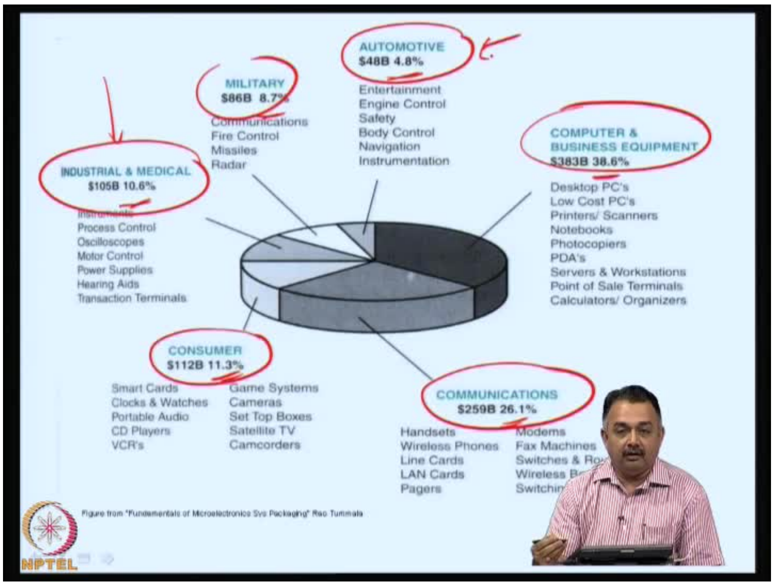

Today, I will take you through the various application areas that I have briefly mentioned in the first class. We will discuss some representative products in each of these areas and we will also slowly get to a point, where we can define what packaging is, so that, with the background that we have from the last two hours, we will be able to define what packaging is. Look at this figure (Refer Slide Time: 06:06); of course, this figure is slightly old, in the sense that it is about five to six years old, but, if you look at the percentages in each of the sectors, it is more or less valid.

We will look at it one by one. If you look at the overall picture, the major share comes from computer and business equipment. We can see the volume of business and the percentage of market share globally and revenues earned. Then comes communication systems; then comes the very important consumer electronics and industrial and medical systems; this can be fairly a large system. And we have specialized areas like military and automotive; automotive is a very growing sector; packaging for automotive is in a phased growth, well defined; the volume is small, but, at the same time the consumer demands in automotive are also fairly complex.

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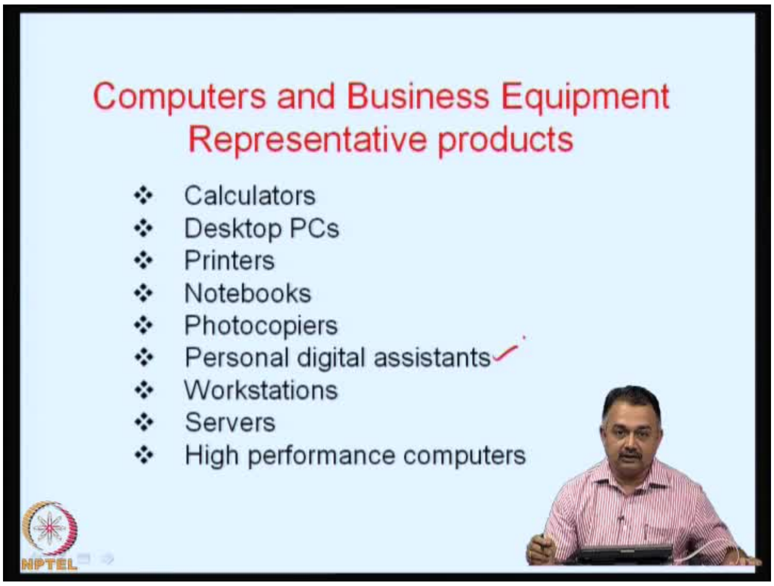

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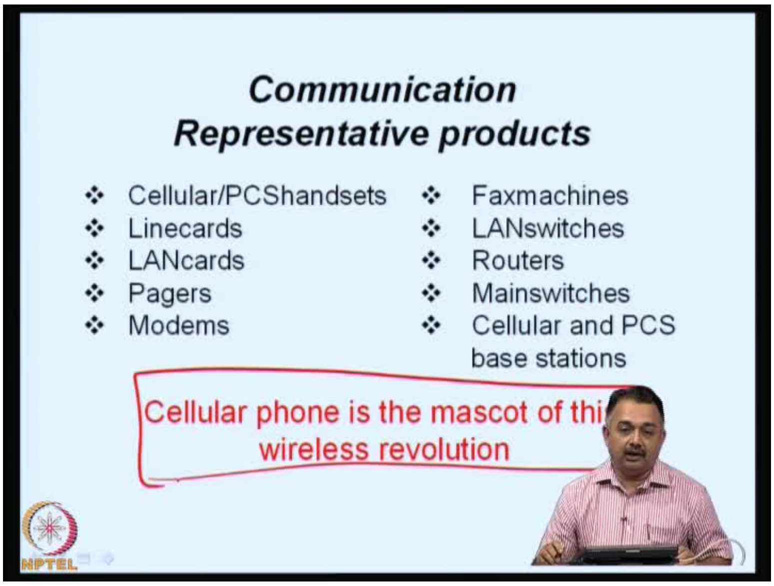

We will look at it one by one, all of these sectors. If you look at computers and business equipment, the representative products are calculators, desktop Personal Computers, printers, notebooks, photocopiers, Personal Digital Assistants, workstations, servers and high performance computers. Some of the products are very common; used in virtually every office and home; and are very essential products. So, you can see the volume of business in these areas is very large. You can look at representative products in communication, where you can see high growth and high volume: cellular, Personal Communications Service handsets, linecards, Local Area Network cards, pagers, modems, fax machines, Local Area Network switches, routers, main switches, cellular and Personal Communications Service base stations. One thing that can be said about the entire scenario in communication products is that the cellular phone is the mascot of this wireless revolution.

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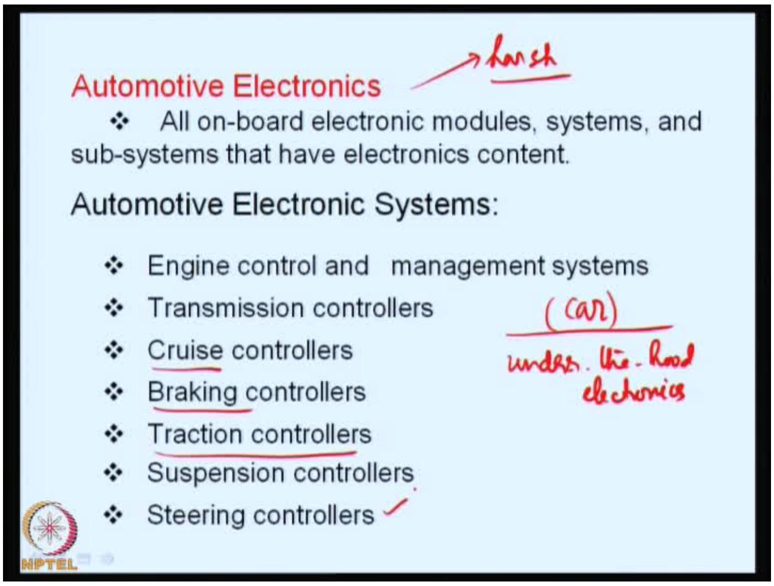

Today, if you talk about packaging in communication, everybody talks about the cellular phone. Then comes automotive electronics; in automotive electronics, as I said before, we have complex systems, because if you take a car for an example, an automobile, the space available for the electronics is very small; we talk about under-the-hood electronics - all the electronics has to be built under-the-hood in atmospheres or conditions where it is very harsh.

We can say automotive electronics will deal with harsh environment. So, the packaging engineer or design engineers for systems and subsystems that work with automotive electronics need to be aware about the harsh environment that the system will have to work with reliably, over period of time. Let us look at the representative products in automotive electronics or automotive electronic systems: The first thing is engine control and management systems, very important; transmission controllers; cruise controllers - today’s cars come with auto cruise facility and therefore, you need to control the speed of the automobile and give information to the navigator or the driver about the cruise controlled mechanism and safety regulations also; Braking controllers; Traction controllers; Suspension controllers; Steering controllers. You see, new models of automotive cars are in the market today.

Some cars come with as much as fifty to fifty five microprocessors under-the-hood, distributed in various sections of the car or the automobile. Now all of these information have to be displayed to the navigator or the driver periodically, so that the journey is safe; all information about, for example, the condition of the four tires, the air pressure in the tires and the fuel management system information. All of this information need to be displayed on the dashboard of the car. Today's consumers or the end users require such information. This is the specialized requirement.

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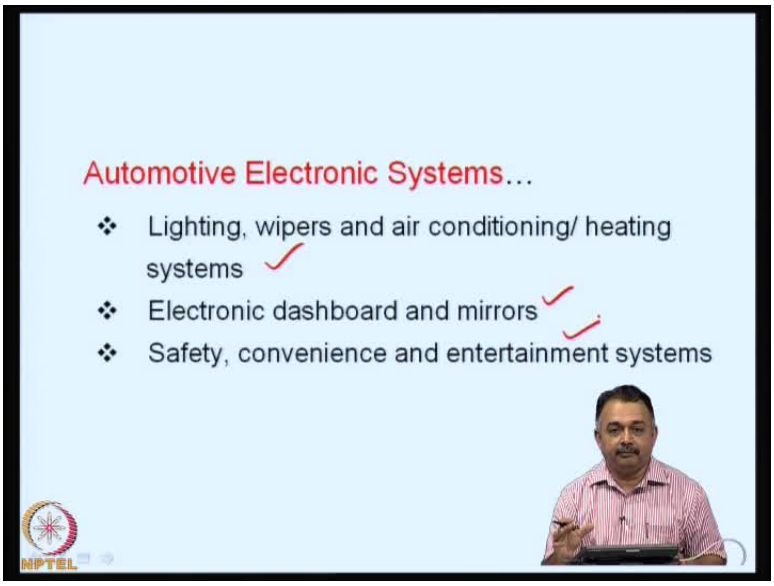

Of course, there is a question of cost getting into it, but consumers do not really mind paying that. Every industry specializing in car manufacturing have very high end systems which have these facilities. These are special requirements, not all cars require this, but high end systems will need to have this, because there consumers who require this. Other subsystems in the automotive electronic systems will be: lighting, wipers, air conditioning and heating systems; electronic dashboard and mirrors; safety convenience and entertainment systems. How do you manage all of the systems keeping the electronic systems small, but at the same time jelling well with the mechanical parts of the automobile? And, as you know when a car is driven on the road, there is a lot of vibration; there can be roads which are not really very flat; there can be conditions where the road is a desert; water. There can be instances where under-the-hood, you have corrosive atmosphere because of air, dust, water and so on. We are looking at the system which is very complex, where our electronic package or system level boards perform reliably.

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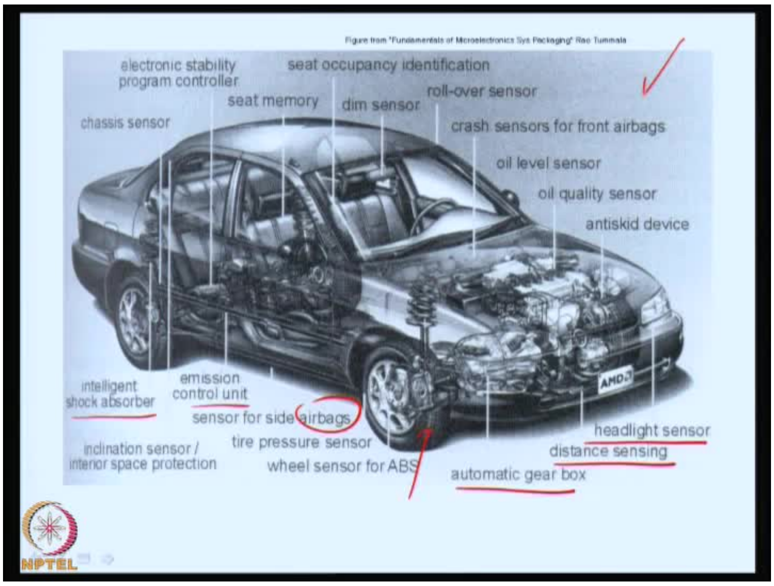

This is an example; as you can see here in this figure, this is an example of the places or the locations where you will find electronics and where the automobile manufactures need to build systems which are reliable. For example, you can see information that is needed to be displayed on the dashboard about the shock absorber, about the emission control unit, safety regulations like airbags - they need to perform when there is a an accident and which effects the great impact cost on the car which effects the passengers. So safety is one thing we look at, when you include electronic systems in automobiles.

There are other situations which continuously needs to be monitored, for example, automatic gear box information, headlight sensor, distance sensing and, for example, if you have electronic information like General Packet Radio Service, when you‘re travelling long distance; you need to connect to wireless; connect to various service providers and those information needs to be displayed on the dashboard.

These are some of the very important electronic subsystems built for automobiles today. For example, I give an very nice situation which can become a very important packaging problem: If you want to monitor the air pressure of your tires continuously and display it on to a dashboard, you need to have sensors that go into the tire, very small sensors that continuously measures the pressure in the tire and displays it onto your dashboard

These are all not required for all cars - medium range cars or low range cars, but there is a segment that requires all this information. Very soon you will see these things become routine manufacturing add-ons that you can expect.

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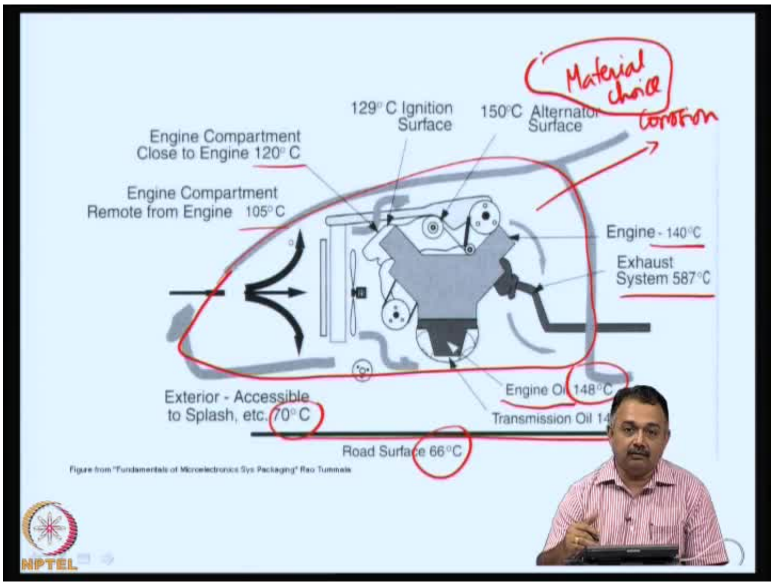

Now, if you look at the corrosive atmosphere that is there in the hood; as you can see, this is under the hood. We can look at the picture; this is the front of the car and you can see there can be various situations where your system or system level boards can be located. We need to monitor various things like the volume of engine oil present and while working the temperatures are denoted here (Refer Slide Time: 16:47), the engine, for example, has a surface temperature, at the metal body, of 140 degrees. Exhaust system is exhibiting a temperature around 587 degrees C.

Engine compartment close to the engine is at 120 degrees C; engine compartment remote from engine is fairly better, 105 degrees; exterior, along 70 degrees. You can see that the road surface, the friction exhibited on the car is moving, is at around 66 degrees C. You can see that your systems have to perform under these conditions and then when you have moisture, dust and other situations which can easily cause corrosion or situations that can lead to failure or reduce the reliability, then, this is a big design test for manufacturers.

When you do a design for such a system, you need to take into account all of these considerations. Therefore, the material choice becomes very important.

You have to really carefully consider what kind of materials need to be used, when you package an Integrated Circuit, that is going to be used in an automobile under-the-hood application and when that particular packaged Integrated Circuit is going to be mounted on a substrate, we have to look at what kind of substrate you can use, that can perform reliably over a period of time, under these adverse or harsh conditions.

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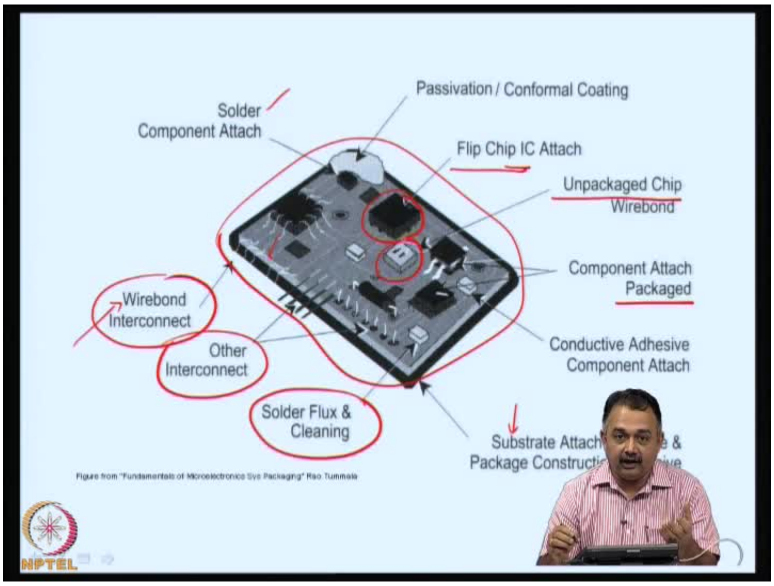

This figure, probably, is a bit too early, but I will try to explain how, for such an automotive electronic system, you have a situation where you have a system level board. This is a system level board, where the individual Integrated Circuits are packaged and mounted on a substrate. The first thing we have to worry about is: what kind of substrate you need to use? What I am giving is, for automotive electronics, an example

This similar case study can be extended to a communication system, an Uninterruptible Power Supply system or a Switched-Mode Power Supply system and so on. We will deal with such case studies as we go on. For example, if you are using an Integrated Circuit, which is of the classification called Flip Chip, how do you take care of it; how do you protect this Integrated Circuit, when you mount this on a substrate that is going to be used in an automobile application?

What kind of solder material you will use? What is the interconnect mechanism that you will use within the Integrated Circuit or connecting the device to the substrate? Is it a Wire bond or some other connection choice? We are going to see that. Then, during the process, have we taken care of cleaning residues that can possibly effect in terms of corrosion and so on; it can reduce the reliability of the board.

What kind of package material you have used? If you are using an unpackaged chip on-board, how do you protect it? These are all some situations that I am trying to give beforehand, which will be dealt with, during the course of these lectures.

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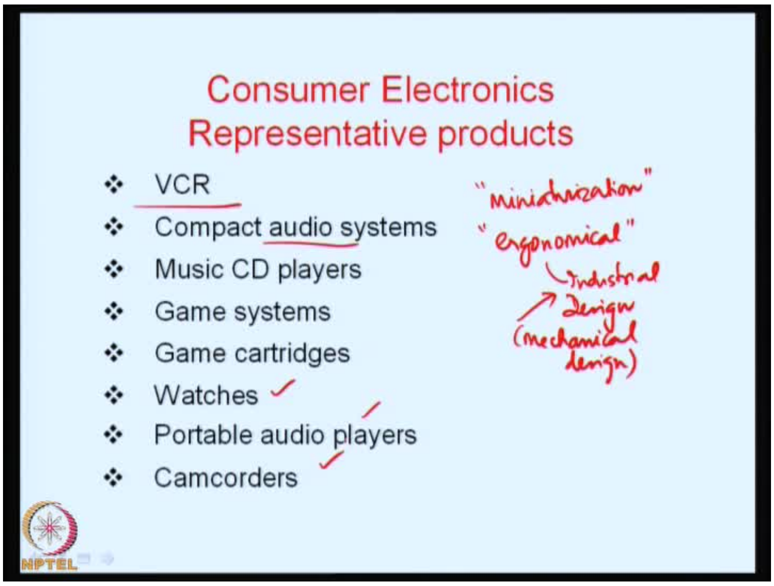

We have seen automotive electronics. Now, we are going to look at consumer electronics and some of their representative products. Video Cassette Recorders, which are very outdated today; audio systems - these are all, again, shrinking today, you can recollect large audio systems and players that were present over the last 5 years, but today, here again, you have seen a large growth and we have seen miniaturization, compactness and more ergonomics.

By ergonomical, I mean the user friendliness - man to machine friendly design. Lot of industrial design also goes into this. Upfront, I would like to say that, when a product is packaged, you also take care of industrial design or you can say mechanical design. This is a very completely different topic, but very essential for product packaging.

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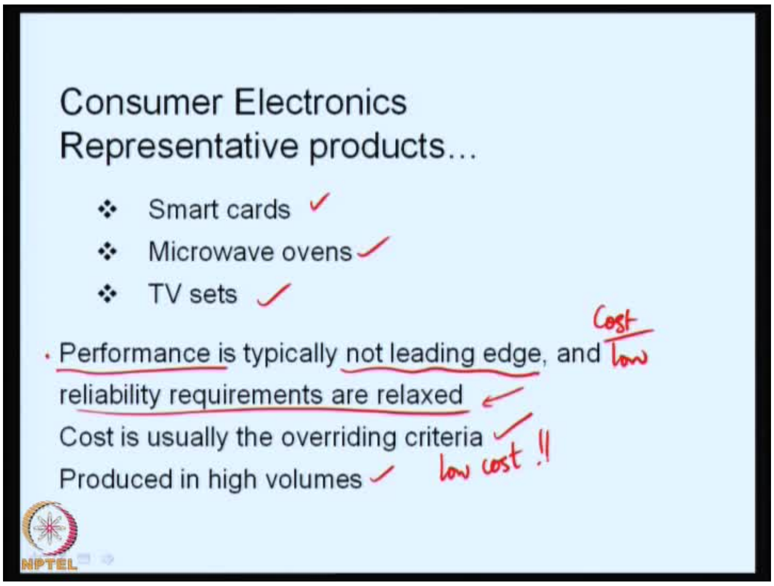

Now, we talk about other representative products: game systems, cartridges, watches, portable audio players, camcorders, cameras and so on. For example, if you take cameras or camcorders today, if you open up the system and see, you will see a very thin flexible substrate, which houses all of your components and are interconnected on the flexible substrate. Earlier days, they were using very rigid devices, for example, this is a very rigid printed wiring board that you see here. This is a very rigid device, today, people are now moving to flexible devices. Why should we move to flexible devices? Because, there is less space in the product and you can flex the entire board and house it in very small areas; so, that aids miniaturization - that is one of the essential features of small handheld products today.

Other products include smart cards, microwave ovens, Television sets and so on. For example, I will show you a smart card; here (Refer Slide Time: 22:56); this is a smart card and you can see here, a device this is essentially seen in all plastic card devices, which are used for money transaction today.

This has got all inbuilt information about your money deposited here; how much you have withdrawn; it can be used for transport or any other consumer retail activity that you can do worldwide. These are all very important consumer electronic products today. As you can see, the performance, here, that we expect is typically not leading edge, compared to a military or a space system or a subsystem and reliability requirements are fairly relaxed, because the cost also needs to be low.

You cannot invest a lot of money to get very high end performance and keep it at a low cost. Cost is usually the overriding criteria, to decide what kind of design implementation, in terms of expensive devices and materials that can be used for consumer electronics. It is usually produced in high volumes and that is why we are able to keep the cost low.

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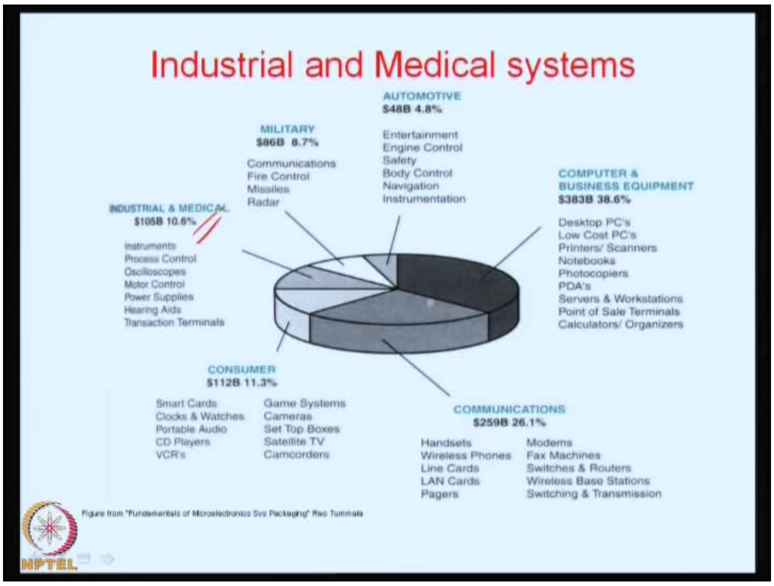

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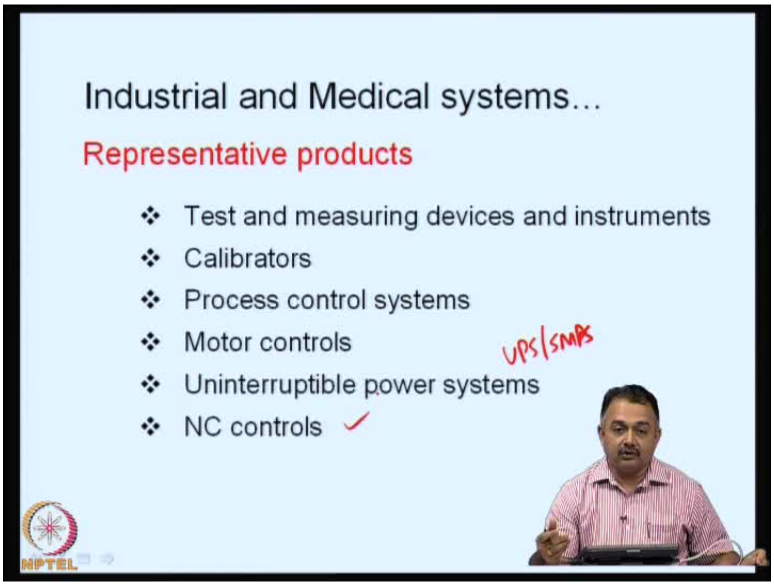

Now, we will go into another sector called the industrial and medical systems. As part of this pie here, you can see industrial and medical systems are about 11 to 12 percent updated figure of the global market system scenario. If you look at the representative products in industrial and medical systems, we talk about test and measuring devices and instruments that are used in medical care and industrial systems. These systems can be very large.

Calibrators, process control systems, motor controls, Uninterruptible Power Supply system or Switched-Mode Power Supply systems and NC controls - numerically controlled equipment, for example, an NC drilling machine and various numerically controlled mechanical systems.

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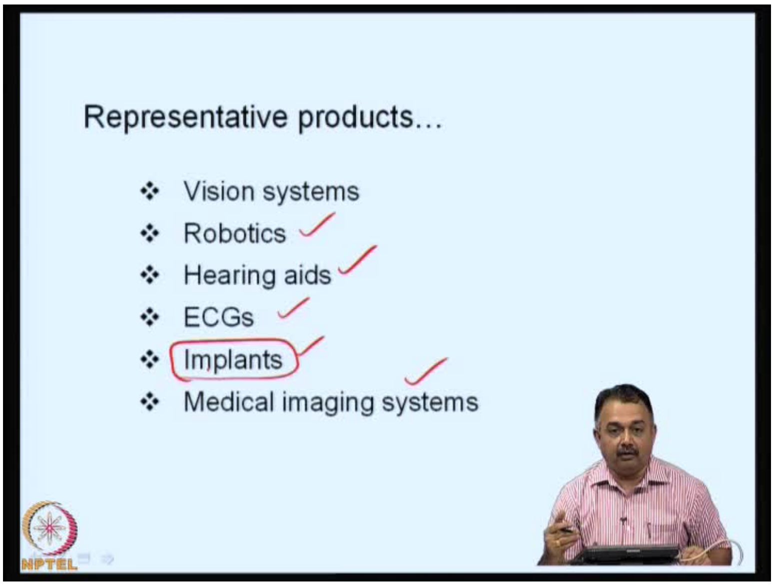

Others products can be, in the health sector: vision systems; robotics - you have seen that today medical surgery and medical care has evolved and new products using robotic surgery; even online distant-help based surgery are now being carried out; hearing aids; Electrocardiography; implants; medical imaging systems - all of these come under the medical care electronic systems. Of these important things that occupy very small area or very small size, is the implants and these directly go into the patient’s body.

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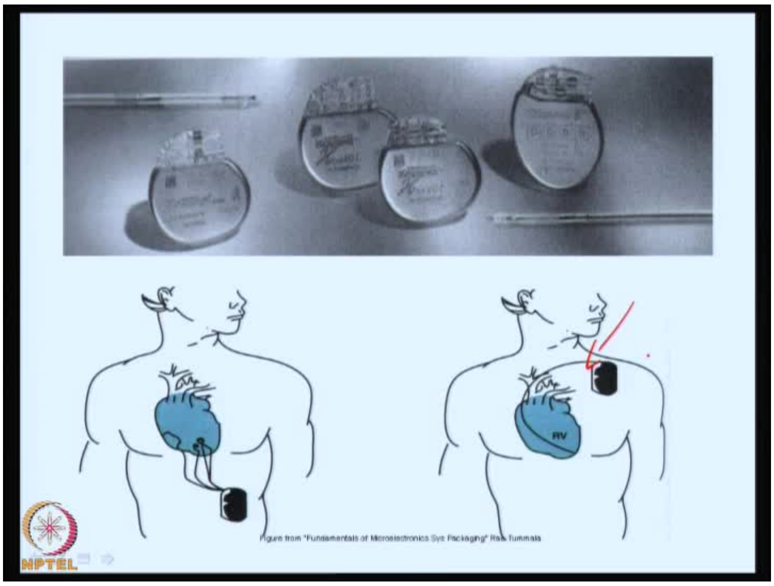

I have a particular example for you, to show. You can see very small systems, for example, there is the pacemaker, that regulates or monitors your heart after surgery or there are certain conditions for some people which needs monitoring the heart beat in the condition of the heart, regularly. Then, in some cases, it needs to be implanted.

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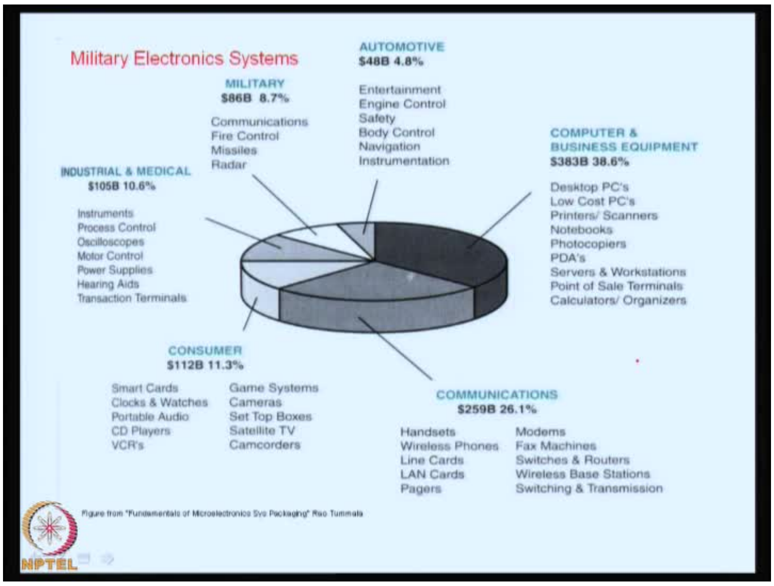

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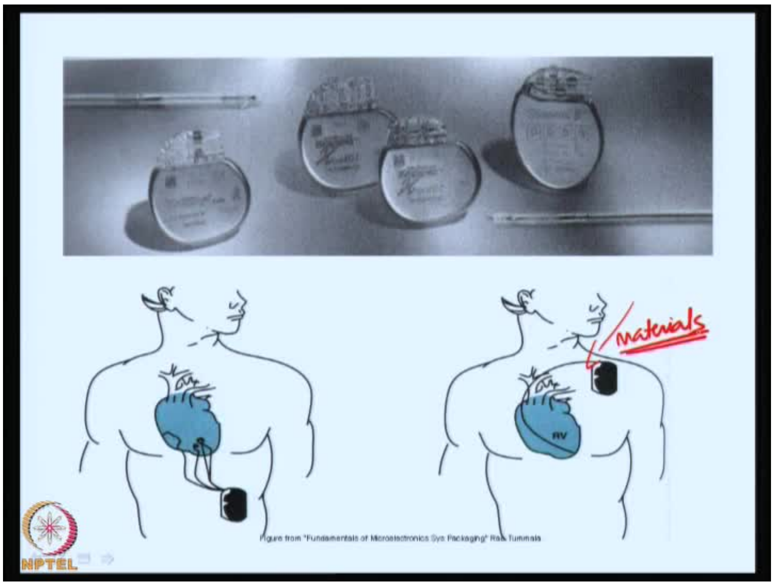

These are devices that are implanted into the human system, close to the location where it needs to be monitored, like your heart. So, the surgeon decides where to implant it, depending on the size of the system, and depending on the nature of the disease. Then this particular device, because it is implanted, needs to be monitored from outside regularly.

The device is in the midst of various fluids, including blood and other bodily fluids that are in contact with your package or the device. As expected you will have to think about or the companies which market these will have to very seriously consider the materials that needs to be used for these devices that go into the human system.

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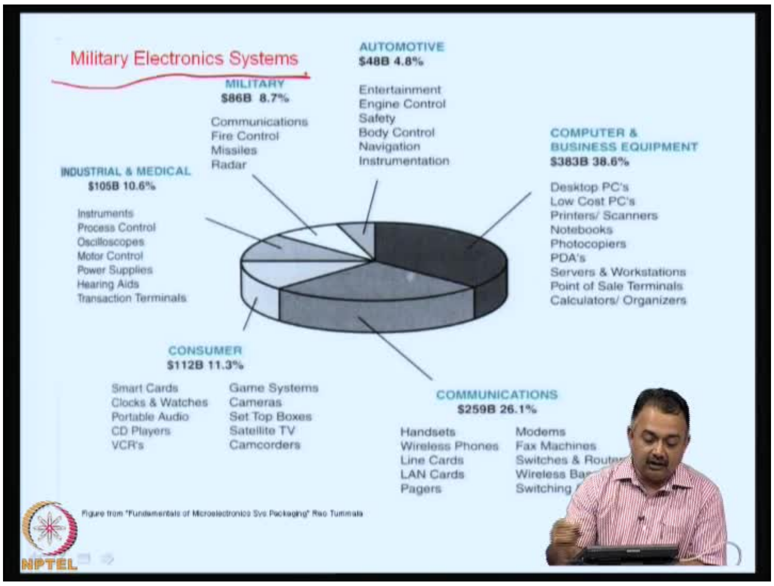

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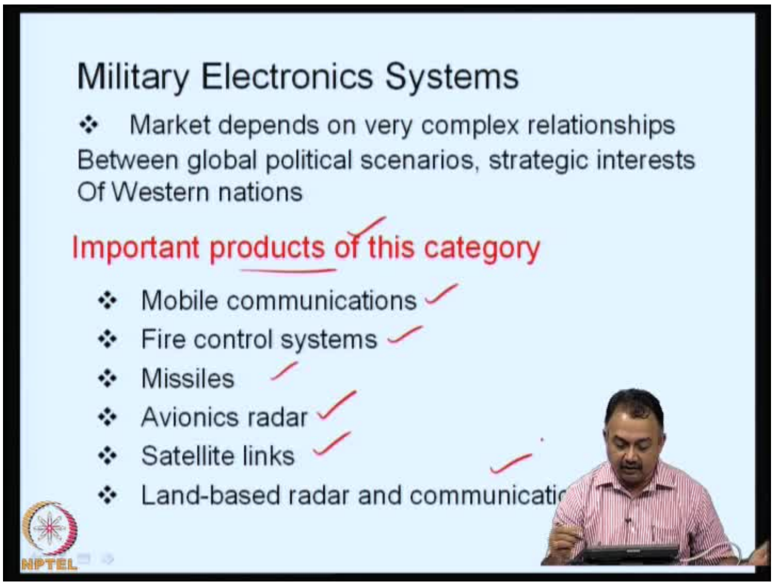

Because, it should not be affected by the various fluids that are present; it should not chemically react; it should not dissolve. These are some of the very essential packaging requirements. You get a flavor about the consumer electronics, the automotive electronic systems, medical care and industrial systems. All have very different preset requirements for packaging.

Now, we will get into another area, which is Military Electronic Systems and we will see some of the representative products. In military electronic systems, the market depends on very complex relationships between various because the growth depends on the current situation of what kind of military buildup each nation requires. The important products in this sector will be mobile communications, fire control systems, missiles, avionics radar, satellite links, land-based radar and communication systems

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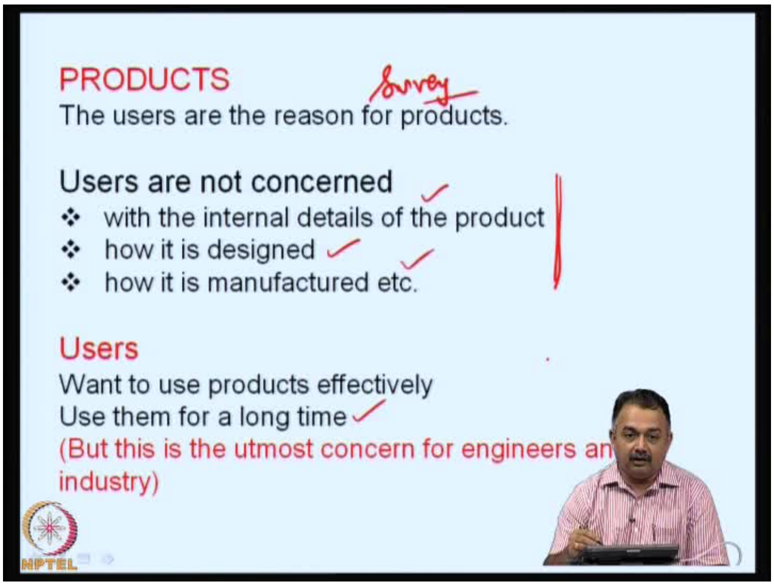

We have gone through the various application areas one by one and we have seen the representative products that are currently being used. Among the list that I have given here, there could be various other systems that are not listed and there can be great variation between the sizes of products in each of these application areas.

The products are the important things for users today and the user dictates what kind of products they want. Normally, a survey is done by the companies to find out what is the interest of the user, and based on that market survey and the user survey, the products are designed. So it is very simple to accept this statement which says that the users are the reason for products.

Users are not concerned with the internal details of the product. If you take the survey, they will say, 'this is what I want; this particular system has to perform this function because I do not have a system that performs that. I would like to see a system perform an advanced functionality.' How it is designed, they are not worried; how it is manufactured, they are not worried; but as an engineer, you have to worry about this.

The user wants to use the products, effectively, for a long time; obviously, when they buy a mobile phone for five thousand rupees, they want to use it for at least five years reliably, without service and repair.

This is the utmost concern for engineers and the industry. We look at it from a different angle and the common man or the users look at it from a different angle, but effectively when you design a product, we also look at these end user concerns.

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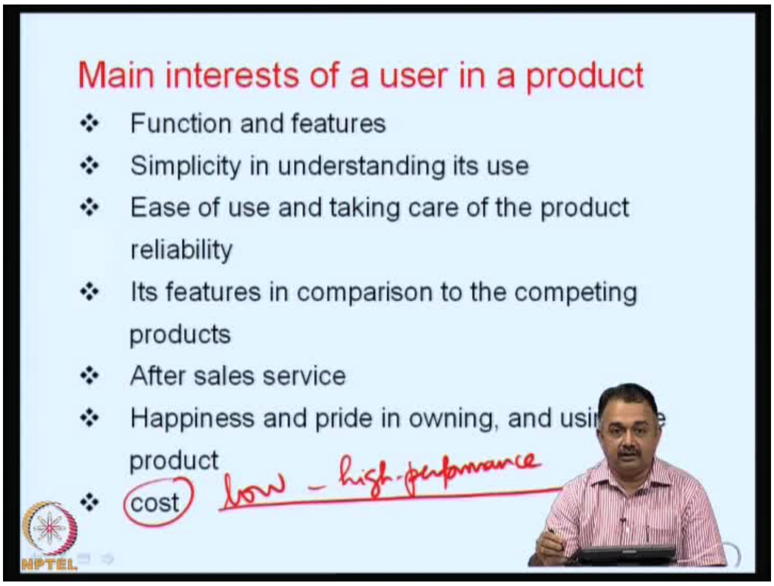

As an engineer, we have to look at what system functionality you can build; what are the features you can have; simplicity in understanding its use; ease of use and taking care of the product reliably; its features in comparison to the competing products - we want to be a leader when an existing product is there in the market today, so, you have to add new features that are much better, compared to the existing product of another company; after sales service happiness; pride in owning and using the product and above all the cost- everybody wants low cost, so, as an engineer, can you build a low cost product with high performance? In a nutshell, I would like to say that in packaging, please remember, this is very important and is a keyword in the industry houses, low cost product, high performances except, as I have said, in some special cases.

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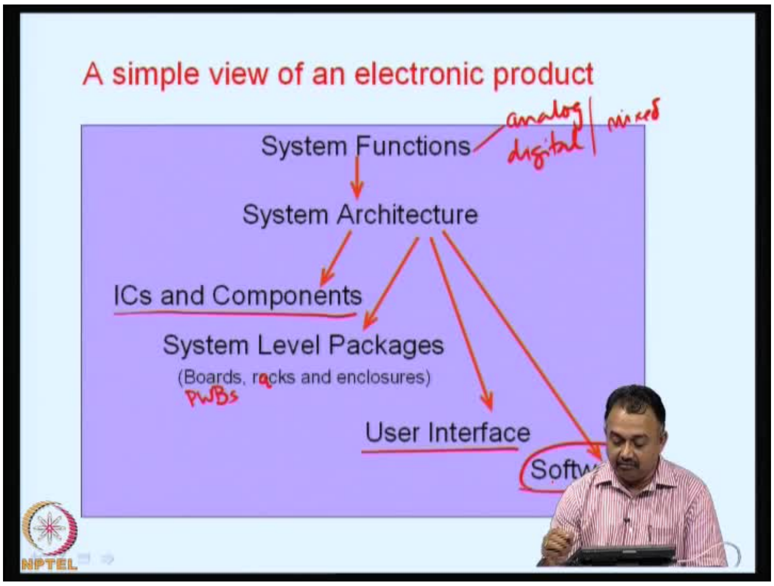

A simple view of an electronic product will be: there will be system functions built; the system functions can be, for example, analog, it can be digital, it can be a mixed signal or it can be high band width system function. It can be Radio Frequency, it can be optical or it can be mixture of each of these, depending on the application area.

There will be a system architecture based on the system functions; then there will be Integrated Circuits and components that perform the system functions individually, and together, when connected; there will be system level packages, that is, printed wiring boards, racks and enclosures.

User interface - very important; for example, your Liquid Crystal Display, your touchscreen, your buttons - all of these are user interfaces that connect or communicate instantly to your boards and drags, and then they perform the system functions.

Software, of course, is embedded, and is very important in today's product because without that, it is going to be very difficult to get the type of display and graphics interface that most of us want in hand-held products.

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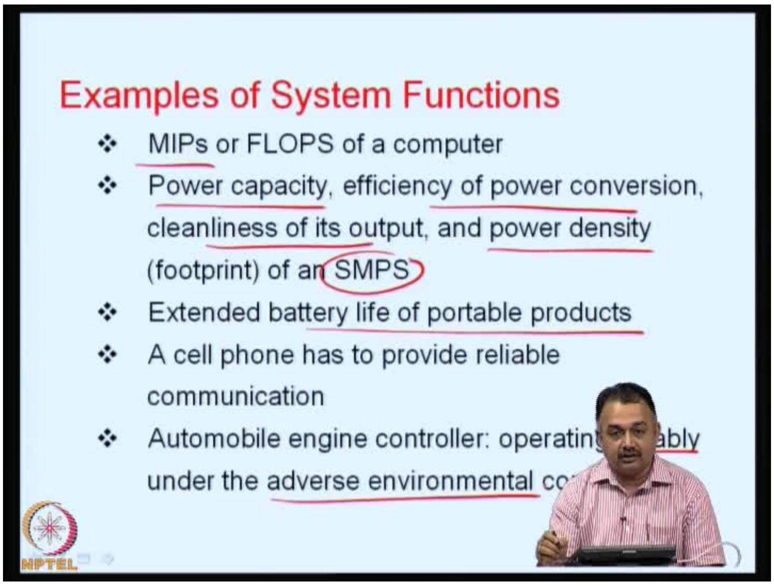

Examples of system functions will be:

The Million Instructions Per Second or Floating-point Operations Per Second of a computer, that is a system function - millions of instructions per second; if you say, for a computer, that means you have defined a system function; you have used a particular processor for that; and you have interconnected other devices around the main processor to get the desired system function, which, in this case, is a MIP - millions of instructions per second.

Power capacity of a product, efficiency of power conversion; that means you have designed something to get, let us say, 99 percent efficiency in power conversion.

Cleanliness of its output, for example, it says that the noise level is very low here; the power density of a Switch Mode Power Supply- all of these are pertaining to a product called switch mode power supply.

Extended battery life of portable products: that is a system function. You would have spent lot of time deciding what battery you will use, and then how to extend the life of the battery, by your associated electronics with your main board or main design. In the case of a cell phone, for example, it has to provide reliable communication; in the case of automobile engine controller, for example, it has to work reliably under adverse or harsh environmental conditions.

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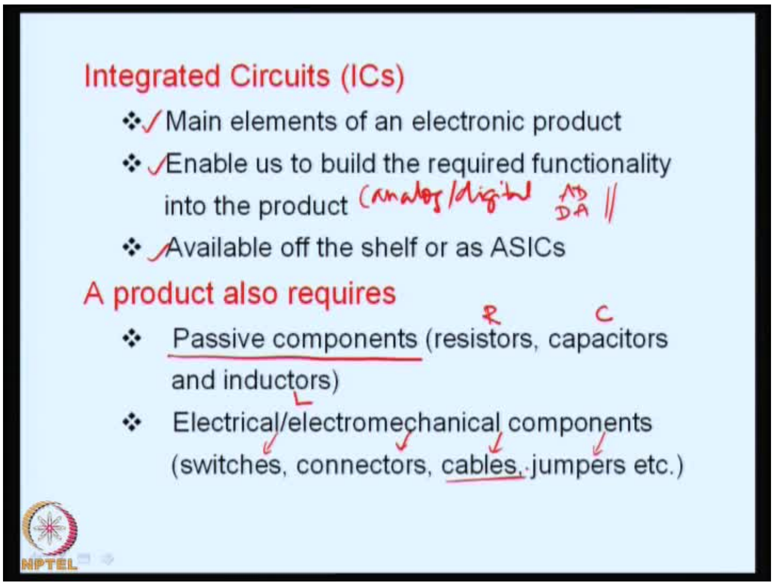

Integrated circuits are the main elements of an electronic product. I hope you can appreciate that, because, integrated circuits or ICs, or active devices that come in different flavors; in different application areas you have different ICs. So, when you design a main system level board, you will decide what type of ICs need to be used for a particular electronic product and how to, among a group of ICs, select, based on reliability and testability. These are the main elements of an electronic product. It enables us to build the required functionality into the product. As I said before, it can be analog, it can be digital or it can be mixed signal; or it can be analog to digital conversion or digital to analog conversion and so on. ICs can be available off the shelf or built as Application-Specific Integrated Circuits.

Now, you can also custom build a group of ICs together, and package them together to get a custom build IC chip-set. The product also requires passive components; this is very important because, if you open up any product today and see, you will see that it not only consists only of the active devices, it also requires passive devices. What are the passive devices? Resistors, capacitors and inductors; resistors and capacitors, obviously are required for most of the electronic products to control your active devices when it is powered up and it is used as filters and so on. Electrical and electro-mechanical components are also required, for example, switches, connectors, cables, jumper wires and so on.

So, if you look at any electronic product, your cellphone, for example, they have switches, membrane switches and they have connectors, which connect the board to the display, for example, Liquid Crystal Display. There can be two or three different boards in a system and each of them are connected by connectors. So, you have to decide what type of connectors you have to use; what is a material contact there, whether it is gold or some other material that can provide very good contact without losing the electrical performance. Cables - if you want to connect a board to a rack of a system, for example, and so on.

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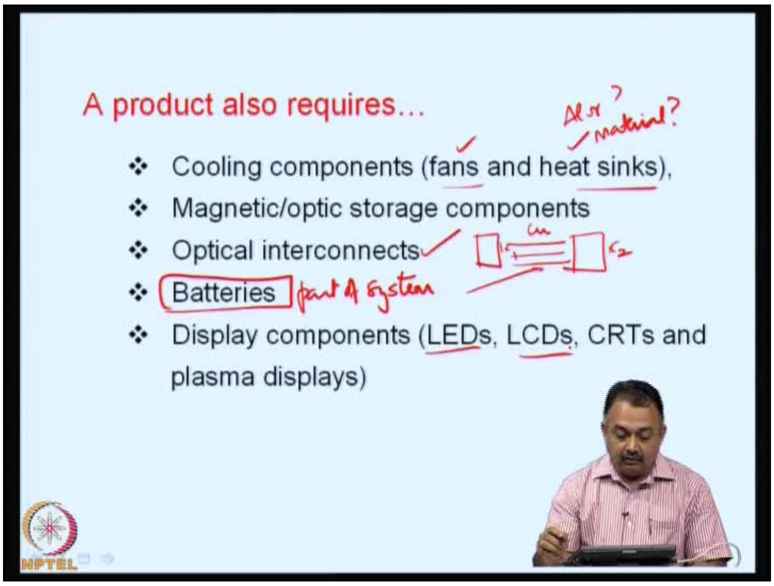

A product also requires cooling components, for example, fans and heat sinks. You would have seen, in personal computers and desktops, fans are being used to remove heat as quickly as possible, when the device is powered up, from the active servers of the IC. We do not want the heat to be built up, if heat is built up on the surface for a long time, then it causes problems to the active device itself. Heat sinks are used to remove heat, if fans are not used. In some cases, heat sinks are used. So, you have to look at what kind of material choice you need to use, if you are using a heat sink, is it aluminum or is it some other metal. Then, you have magnetic and optical storage system; optical interconnects are, today, being used between two devices, for example, if this is IC_1 and if this is IC_2, normally you have connectors or conductors, which is normally copper, but today, people are looking at how to interconnect these two devices by optical methods, so that the signals are clear; there is no loss in signal propagation; and there is less delay in signal propagation; we also look at other various electrical issues that are normally presented with the use of metallic conductor.

Batteries – obviously, very important today; batteries are part of the system today and people are looking at how to integrate batteries into systems very effectively; and display components, as I have mentioned Light Emitting Diodes, Liquid Crystal Displays and so on.

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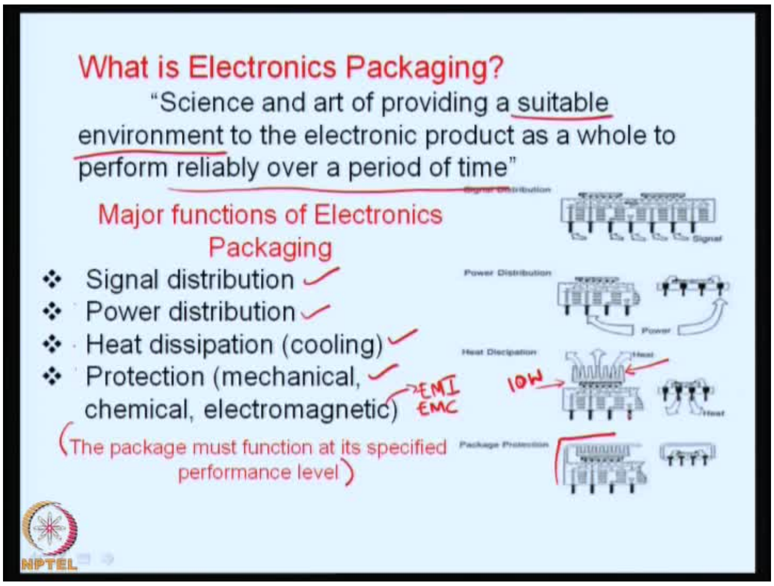

So, you, now, have got have fairly good idea about what a product means, what are the essential requirement for a product from an engineer perspective, after understanding the consumers requirement. Given this background today, I have now reached a point, where I can define, for you, what is electronics packaging. It has taken some while for me to really give you a basis or basic information about product, system and so on. Now is the time to define, what is electronics packaging? It is very difficult, to actually find textbook information about electronics packaging, but we will see, how best we can define and I have taken it from various sources.

A simple example or simple definition for electronics packaging will be: it is a science and art of providing a suitable environment to the electronic product, as a whole, to perform reliably, over a period of time. When you use the word suitable environment, it includes thermal, electrical and other green issues. And you can see the important words saying, reliably over a period of time - very important for a product. When you say reliability, it has to perform reliably; electrical reliability should be built in, thermal reliability should be built in. And the major function of electronics packaging would be efficient signal distribution; efficient power distribution; efficient heat dissipation or cooling of the system for the device; and good protection including mechanical, chemical and electromagnetic. Here, we are going to look at EMI, ElectroMagnetic Interference or electromagnetic compatibility of the system; electromagnetic interferences are always there, when a system is powered up. So, you have to look at, how you can protect a system from these electromagnetic interferences. And the package must perform at these specified performance levels. When you build a product, you give a data sheet or information about what are the specifications of a product and the consumer should be able to realize this specification, at any point of time, when the product is functioning.

If you look at this picture here (Refer Slide Time: 43:19), it relates to the basic points that i have mentioned here; signal distribution, across the board, across the system, efficiently between devices; power distribution from one system or subsystem to the other, which defines the product; heat dissipation, if there is an IC here, and if you want to remove heat, let us say, ten watts, how efficiently are going to remove this heat? Are you going to use a heat sink, are you going to use a fan or some other method of cooling?; What kind of materials will you use, so that the heat transfer is efficient?; Package protection- are you going to use an inorganic package protection or an organic package protection, so that your system stays reliable.

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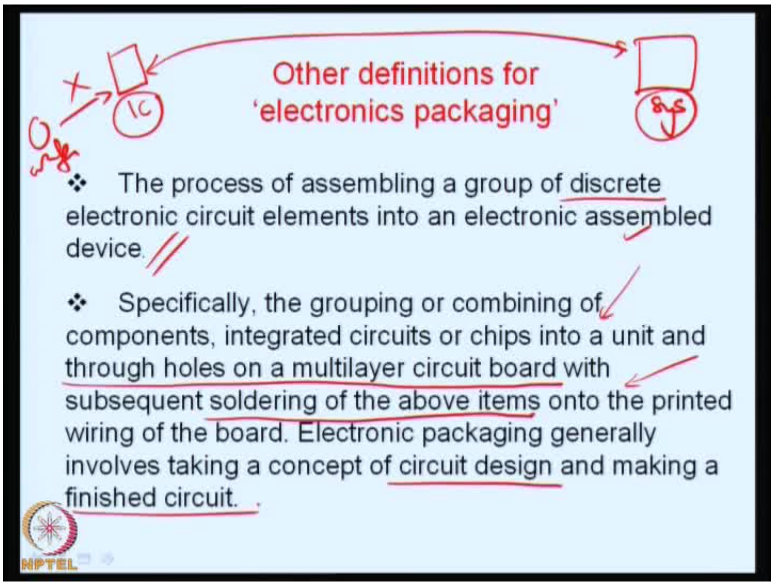

Other definitions for electronic packaging, which I have collected from various sources, I would like to put it here: the process of assembling a group of discrete electronic circuit elements into an electronic assembled device; we are not including semiconductor packaging or the manufacturing of ICs, for the semiconductor processing is never included in this electronics packaging device; as I have said before in the first class, what is packaging? If this is an IC that is built, and if you have a system here, anything that happens between the IC and the system is packaging; we, normally, tend to ignore the wafer to the IC; this is actually not included in the definition for packaging; anything or all activity from the IC to the system, which includes packaging individual ICs and so on. This definition says, in relationship to this definition that I have mentioned here, that a group of discrete circuit elements, that is, a group of ICs, transistors, resistors, capacitors and electromechanical device joint together efficiently into an electronic assembled device, which performs system functions.

The other definition that I have brought here is: Specifically, the grouping or combining of components, which include integrated circuits or chips into an unit and through holes on a multilayer circuit board; this talks about second level packaging or board level packaging, we will see that later; with subsequent attachment of the above items onto the printed wiring board. Here we talk about packaged devices; here we talk about second level packaging, on which the package devices are mounted and finally, it also involves taking a concept of a circuit design and making a finished circuit. So, everything starts from a circuit design like your Very-Large-Scale Integration CAD, how you start with the VLSI activity, to get a particular wafer and a chip; here, we talk about a circuit design or CAD for printed wiring board, and we talk about how efficiently these can be managed on a substrate; whether it is an organic or inorganic substrate, and how a system function can be built on that substrate, and eventually, integrated into the enclosure.

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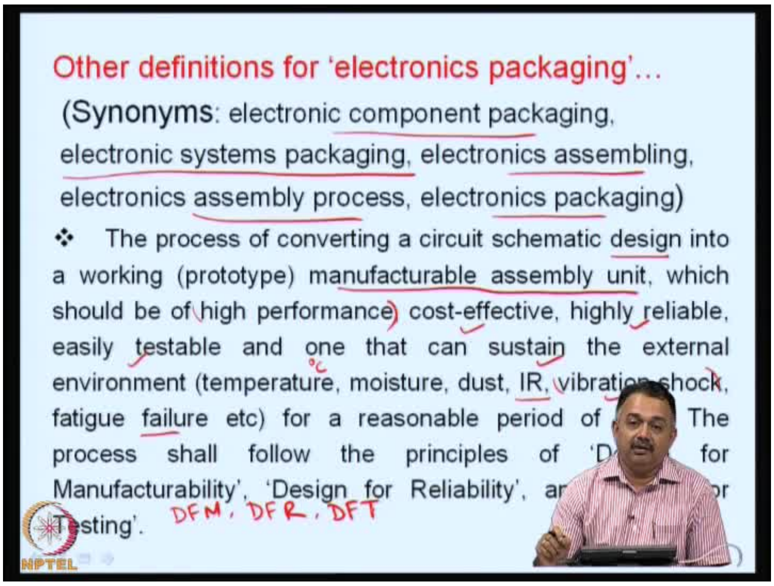

Other definitions as I continue, if you look at any encyclopedia or the web, I have used the term electronic systems packaging, very often, because, it defines the complete system. There can be other terms like electronic assembly, electronic component packaging, electronics assembly process or simply electronics packaging. They are all synonymous with the term electronics packaging. I hope you can follow this. The process of converting a circuit schematic design; we talk about design, into a manufacturable electronic or assembly unit, very important statement, you cannot make a circuit design that is not manufacturable. It has to have all the thoughts gone into whether it can be manufactured or not, if you make a design that is not manufacturable, your precious time and money of making design process is wasted; and it should be of high performance, cost-effective; which i have mentioned and stressed, a number of times here; highly reliable, easily testable; this is something that i want to introduce, easily testable - we do not want to make a system, that once it is manufactured it is very difficult to test it; and then you have to look at issues there can sustain the external environment of the system, that can be temperature, that is, what temperature it is going to work, what is a location, whether it is an dusty area, or a dessert, or a hill station, where it is going to work; moisture, dust, infrared radiation, vibration, shock, fatigue failure, etcetera, for a reasonable period of time. There can be certain application areas like space electronics, for example, where they look at this parameter vibration shock as a very important phenomenon that is always built into the design activity. The process shall also follow the principles of DFM, that is, Design For Manufacturability; then

Design For Reliability and Design For Testability. As an engineer today, I think you must remember these keywords DFM DFR and DFT, because in current industry situation, there is a lot of interaction between designers and manufacturing people. In earlier cases, about a decade ago, this interaction was completely absent. Today, an efficient product is created because designers talk with manufacturers; designers talk with test engineers; and designers talk with reliability engineers, so that they can evolve a very nice design that can be manufactured.

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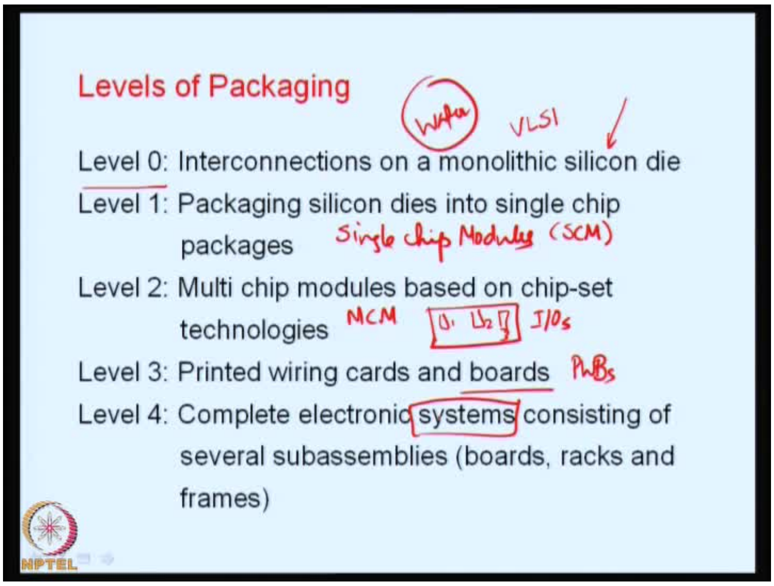

Now, we come to a slide where I am going to define Levels of Packaging. Level 0- if you can call this, it is interconnections on the monolithic silicon die, that is, your VLSI activity and level 1 is packaging silicon dies into single chip modules or single chip packages; you can call it as SCM, single chip modules. Here, as you can see, it is called level 0, because it really does not come into the range of electronics systems packaging because as packaging engineers, we need to know the silicon process definitely, but we are taking the die and then looking at packaging options. This is up to the wafer build and from the wafer it is singulated into single chip modules. Then we have multichip modules, based on chip set technologies.

For example, you can built multichip module, which is abbreviated as MCM; you can take a group of ICs together - IC_1, IC_2 and IC_3 and interconnect them on a single substrate or a common substrate to form a multichip module. The individual ICs - IC_1,

IC_2 and IC_3 can come from different companies; it can perform different system functions, one can be an analog IC, one can be a digital IC, one can be, for example, memory IC; so, these can be interconnected to form a multichip module. This will have its own set of IOs - input output pins, and then can be mounted as a single chip module onto a substrate organic or inorganic.

Then we have printed wiring cards or printed wiring boards and then the level 4 is called the complete system. It will consist of several subassemblies, which are interconnected by connectors; it can be connected by wires in some cases and finally, this system will go or go into mechanical enclosure that is the part of the mechanical design; that is part of the industrial design activity. What I will try to show now is, in the earlier class, I have showed you what a wafer is, now, we have defined or understood what level 1 is; and what is level one? It is a single chip module. Now, this is a single chip module, this is called dip package. If you rip open this and see inside, you will see a bare die interconnected to the leads that you have seen here, on the outside; these are the IOs . This is a single chip module. Now another single chip module is here, but the configuration is somewhat different compared to this; this is again a single chip module it contains one IC inside.

Now, typically, if you look at this device here, this contains a group of four unpackaged die, bare die you can see, and these are interconnected on a common substrate and this can be packaged, like this device, it can be packaged with an encapsulant here and this will have its own set of IOs, and this will be a multichip module. In this case there are four die or dies that are interconnected on a common substrate. I will also show you a very advanced single chip module; we can see a bare die on a simple substrate and then on the other side you will see solder balls, which represent the input output pins of the device; since this contains only one chip, this is called a single chip module and I have shown this sample before; this is again Intel Pentium processor and this has input in the form of a pins. Typically, if you open up and see, this can contain a single chip or multichip module depending on the functionality built.

Now, I want to show you an unpackaged die. This is a one rupee coin and I want to show you the size of a unpackaged die; you can see the kind of integration that has been built into a bare die; typically, such dies are packaged in the form of a quad flat pack like this, and then they input output leads are built so that you can handle them. As we go along in this series, you are going to see different types of packages that are going to be built and we will also see current package, for example, this is a chip size package, again I am putting it close to the one rupee coin, you can see this here is a very small device but, packaged, whereas, here you see unpackaged die; this is a packaged die.

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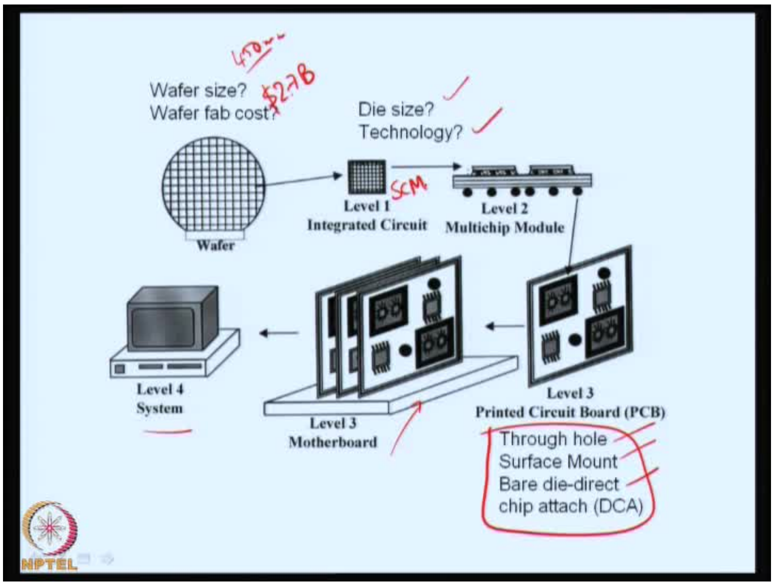

A packaged die, which is almost the same size of a unpackaged die; how it performs what are the criteria or what are the situations when you can use an unpackaged die and when you need to package it, are some other issues that we will be looking at. This figure represents what we have just discussed, from wafer to level 1, level 2 - multichip module level 3 - printed circuit board; level 3 is a set of cards which forms the motherboard, on the motherboard and level 4 is a system; your system can be a mobile phone; it can be a PC; it can be a laptop; it can be a camcorder; whatever. In PCB, printed circuit board, we are going to look at various technologies like through-hole technology, surface mount technology, direct chip attach methodology; and there will be opportunities for me to show some tutorials and some video clips on each of these technologies.

Here, please remember the wafer size, very important, dictates the cost of the semiconductor manufacturing; as we know we are in the four fifty mm silicon wafer diameter- wafer fabrication cost, I have indicated in the last class, something like 2.7 billion dollars to setup a fab; and the die size, from the wafer depends on what kind of package you want to make and the number of IOs that you want whether it is going to be

600 IOs or 4000 IOs and so on; and what kind of technology we will use to package this single chip module, this is a single chip module, whether you are going to use a solder ball interconnect technology; or do you going to use simple pins, as input output leads.

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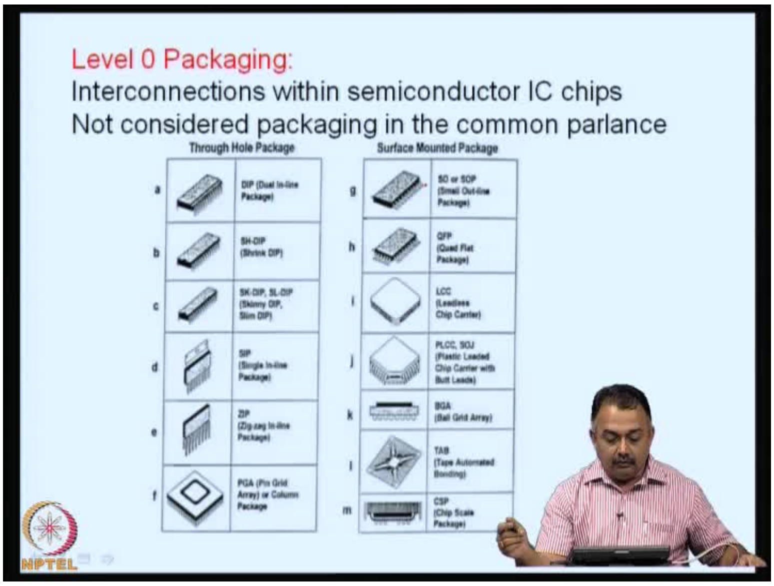

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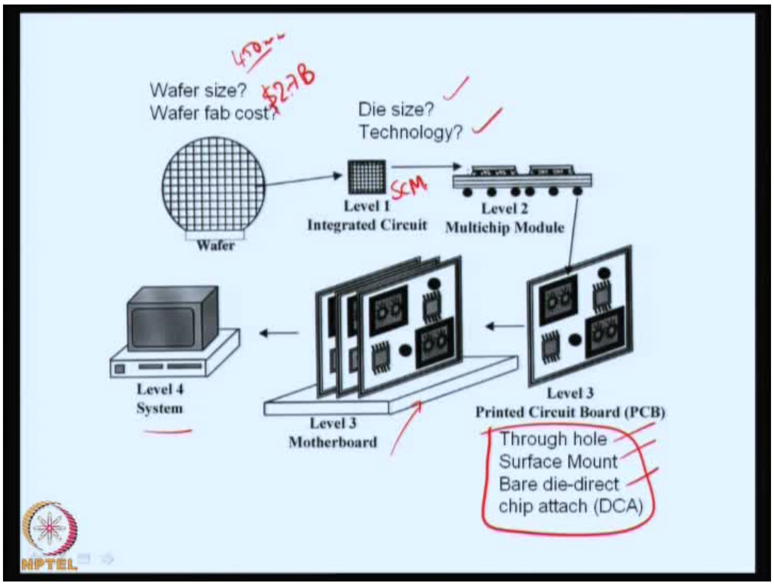

I will stop here for this particular hour, and basically what we have seen in this hour today is, we have seen the entire sector of packaging different application areas; we have seen the individual representative products in each of this areas; we have defined what electronics packaging is; this will give an idea about the activities in electronic systems packaging; leave alone the semiconductor packaging; then we have tried to look at what are the levels of packaging- level 0, 1, 2, 3 and 4; we have also seen some representative samples I have shown here in the display.

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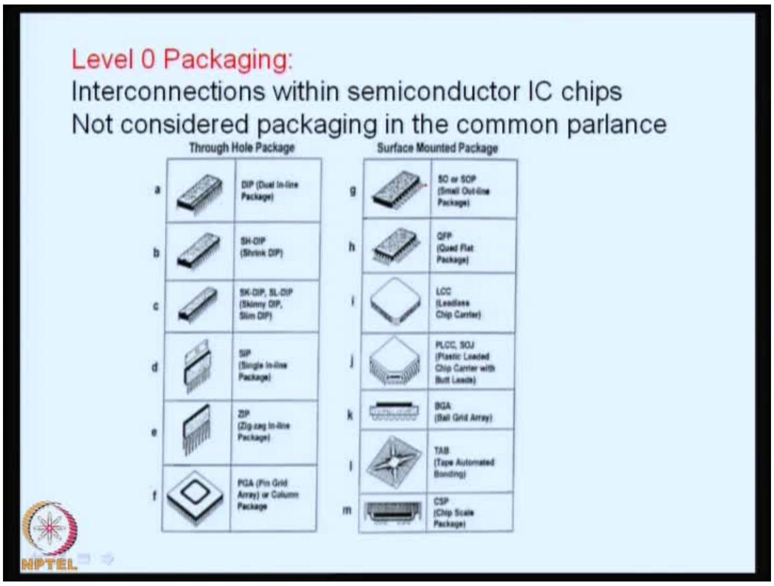

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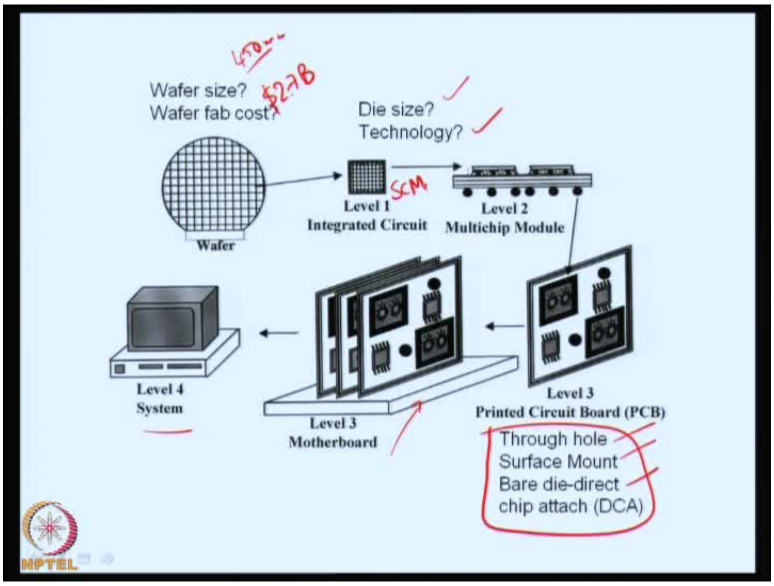

The next class, we will look at, again various examples in the various levels of packaging and try to look at some case studies. As a packaging engineer, what you need to look at, in terms of, when you start designing a product; that will be in the next hour. Thank you.