An Introduction to Electronics Systems Packaging

Prof. G. V. Mahesh

Department of Electronic Systems Engineering

Indian Institute of Science, Bangalore

Module No. # 01

Lecture No. # 05

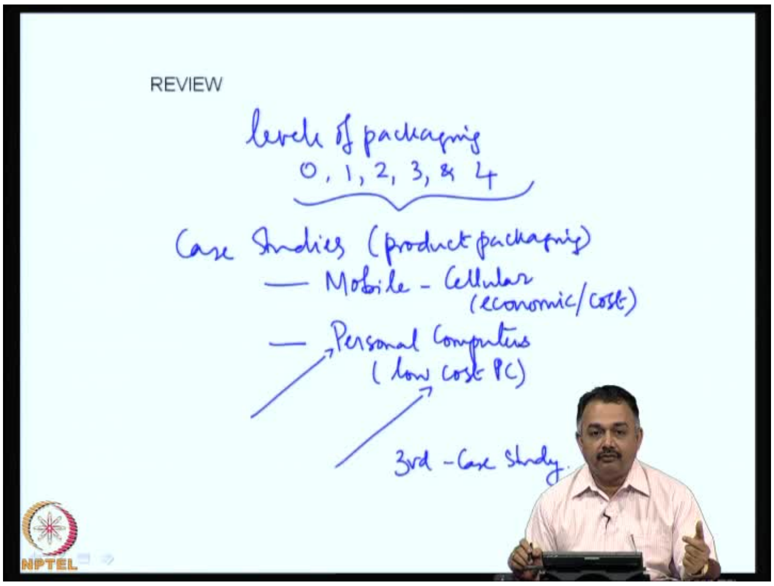
Case Study (continued)

Definition of PWB, Summary and Questions for review

Welcome back. This is yet another class in the Electronic Systems Packaging Course. We are almost at the end of chapter 1. As you know, chapter 1 or module 1 is related to or entitled as Overview of Electronic Systems Packaging. So, we have seen very many basic fundamental items or ideas and definitions. So, I hope you are on the same page as I am. So, we will now move to the next chapter after finishing few final conclusive items in chapter 1.

Now, if you want to recap a bit, which I think is much better. What we have seen in last class is- all the levels of packaging.

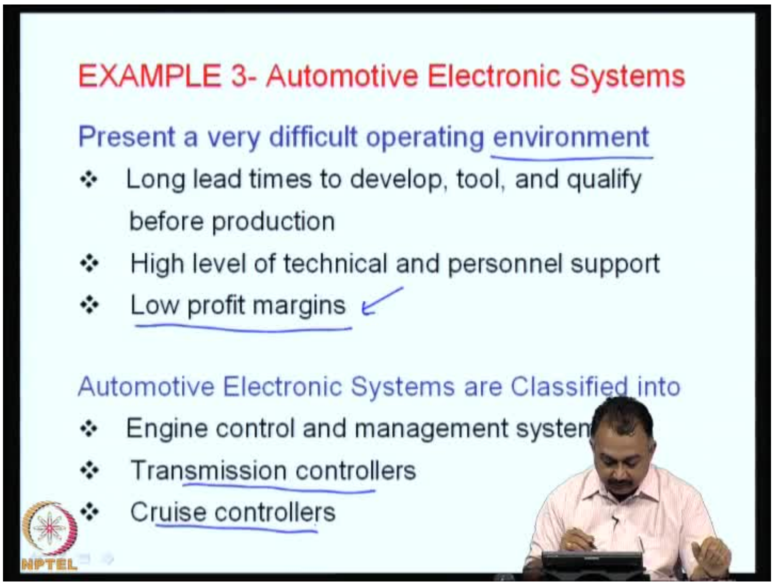
(Refer Slide Time: 01:12)



If you recollect, we have seen what is level 0, level 1, 2, 3 and 4. By now, you must be very familiar with what are the exact areas falling under each of these levels of packaging. Now, we also started looking at some case studies. If you recollect the first case study, this case study is about product packaging and has examples of product packaging. So, what a design engineer should really look into, if you are concerned with design of product from start to finish, including mechanical aspects. So, the first case study application area that we looked at was mobile phones or cellular phones. These are all the various items including the economic factors, cost and so on. Manufacturing is related to cost. I think we are very clear about these packaging aspects.

The next part of the case study or the next example that we looked at was personal computer - Personal computers including low cost PC. I have mentioned you before, a very important phenomenon: depending upon the area, the cost of the product is determined through design. Accordingly, the materials are chosen for manufacturimg. So, in personal computers, if it is a desktop computer, then you will get the designs to fix the cost. Accordingly, the packaging also takes place. We also saw how to make it low cost by choosing different set of materials and choosing different packaging aspects.

(Refer Slide Time: 03:36)

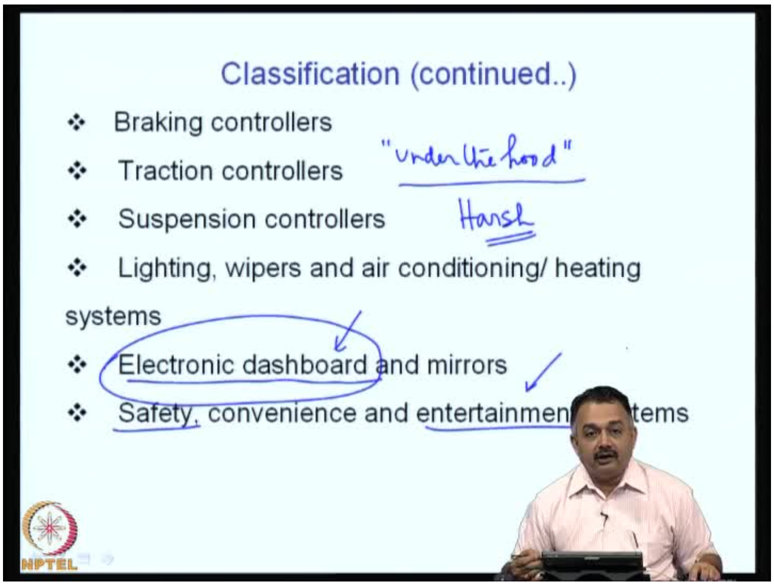


Today, we are going to look at the third example in case study. It will be in the area of automobiles. So, example 3, I have given here a Automotive Electronic Systems. These automotive electronic systems present a very difficult operating environment. I hope you can agree with that. When we say environment, the application area and the environment with which, it is put to use day to day. So, when we say automotive electronics, for our very simple understanding - a car -. As we have to look at volume operations, volume manufacturing. For us, the best example will be an automotive system like a car.

Typically, there are long lead time to develop an electronic system for this application. Develop tools and qualify before production. High level of technical and personnel support is required and low profit margins. Why do we say low profit margins? It is because if you compare a cell phone or a mobile phone industry, the volumes here in automobiles are definitely less compared to the other industry. Therefore, profits will come, only if you keep the price tag very high, for that the electronic systems will have to be high-end performance. So, you will have relatively very few customers taking it. So these are all inter-related. Cost, volume, the level of a packaging or the level of technology have been integrated in to the electronic system. So, please remember these items for automobile systems.

Automotive electronic systems can be classified into engine control and management systems. We have seen this points earlier, but I will try to put it back again. Transmission controllers; lot of circuit design has to go in to transmission controllers. Cruise controllers These are all placed under the hood.

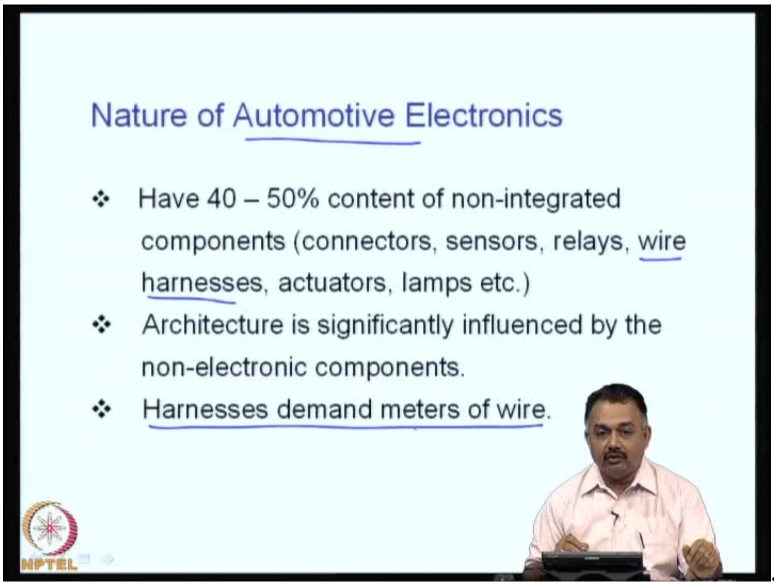
(Refer Slide Time: 05:43)



Please remember this term under the hood, under the hood products, under the hood applications because under the hood of the automobile, the environment is very harsh. The temperatures are very high. There can be atmosphere, which can be corrosive in nature. Therefore, your electronic products need to be packaged and enclosed in such a way that they will not be affected by these environmental conditions.

Braking controllers, traction controllers, suspension controllers, lighting, wipers, air conditioning systems, heating systems, electronic dashboard and mirrors will probably be the place where most of your information from other parts of the automobile will be displayed. So, the electronic dashboard is a sort of a convergence area for display. So, most of the display, whether it is a tyre pressure information or fuel condition or status or whether all of these above systems controllers, the engine level, the brake conditions and so on. Everything is going to be displayed at the front dash board and therefore lot of electronics up to this point will have to be looked at. Safety electronics means safety devices need to be monitored and they should function reliably when such a situation arises. Convenience and entertainment systems are all required categories of application in automobiles.

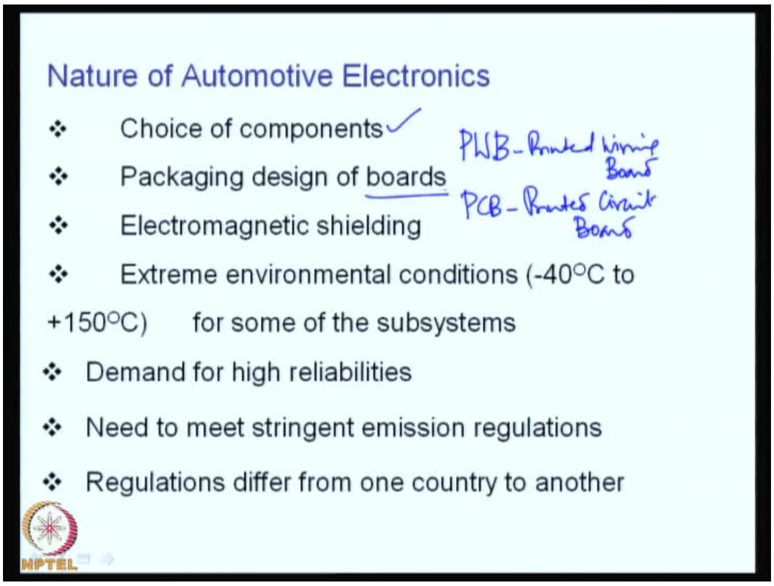
(Refer Slide Time: 07:35)



What is a nature of automotive electronics? As a design engineer, I think you must look into improving technologies in these areas. These are the current status and they have about 40 to 50 percent content of non-integrated components like connectors, sensors, relays, wire harnesses. This is going to take a lot of space under the hood and around the car actuators, lamps. Extra architecture is significantly influenced by the non-electronic components.

If you look at automotive electronics, you can safely say that the active devices will be much less compared to the electro mechanical components like relays, sensors, connectors and so on. They also harness lot of wire throughout the system. In this case, the system is the automobile. So, you can expect lot of wiring to take place because from under the hood to the end of the car to the side of the car and inside the car, you have to do a lot of wiring and they have to be reliable.

(Refer Slide Time: 08:57)

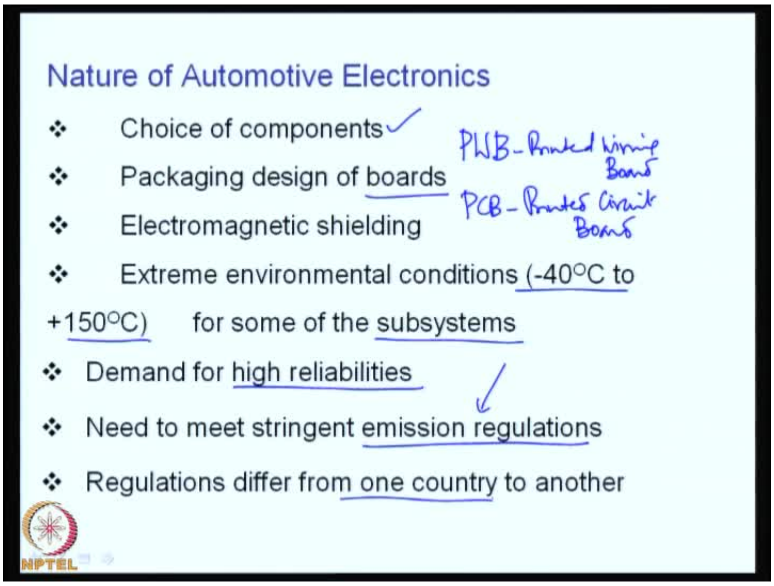


These are the conditions for automotive electronics. As a design engineer, please have a look at the choice of components. Be very careful in selecting what type of components you have to choose for this application. The choice of components for this application will be different to that for a mobile phone or a pc or any other hand-held product because the component has to work in a rugged condition. Therefore, you have to look at the packaging of such an active device or a passive device that you are going to use. So, you have to look at reliability of these components under these conditions.

Packaging design of boards: obviously, you are going to use a board, a PCB like this (Refer Slide Time: 09:42) and it will be used for an automobile. So, let us say this PCB, which is going to be used for the automobile will have a different set of conditions and packaging phenomenon different from other systems. Why should it be different? For example, there are different types of printed wiring boards or printed circuit boards. Now, there are two terms that I have used. So far you would have understood one is a printed wiring board and the other is called a printed circuit board- PCB. You should look in to the literature or the web and these terms are used interchangeably. So, there might be some confusion for you to understand why and when to use PWB or when to use PCB. I will come to that in a very short while. So, how can boards be made more efficient? Can I use a board, which is organic in nature for automotive electronics? Can I use a board, which is ceramic or inorganic in nature for automobiles? So, these are the conditions that you have to look. For example, (Refer Slide Time: 11:04) I am going to show you a board here, which has a bare die on top of it. Now, for an automobile electronics, can I use a bare die and a thin laminate like this? Will it work reliably? So, these are the questions that a design engineer should know. Obviously, you do not want to use bare die, but you want to use a packaged die.

So, here is an example (Refer Slide Time: 11:28) for a packaged die. It will be something like this. As you can see here, this is a packaged die and this is a plastic package. Therefore, a plastic package sitting on an organic substrate is a very good combination for automobile electronics.

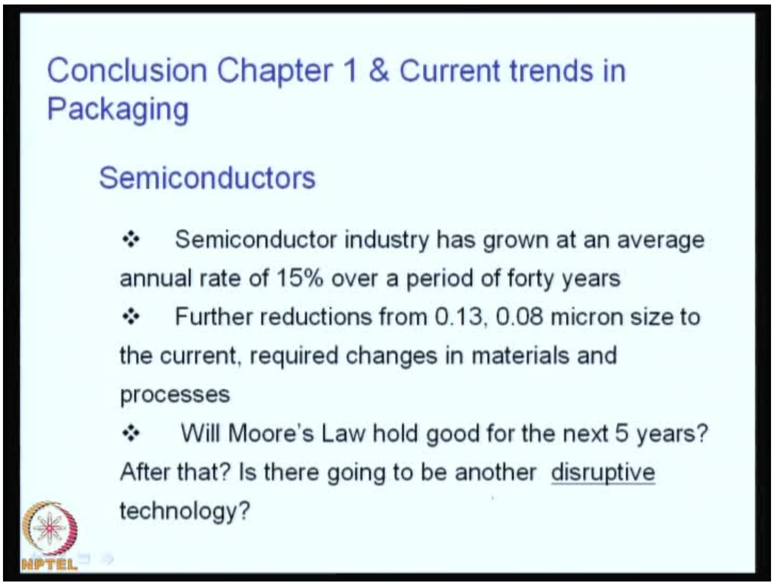
(Refer Slide Time: 08:57)



A company or an industry or design engineer should take these kinds of design decisions at the beginning, before even planning to look at the design aspects of the circuit. You have to take care of emi- electromagnetic shielding very carefully because it is working under adverse conditions.

The environmental conditions as I have emphasized time and again. There can be conditions, where it goes up to 150 degree centigrade. Typically, for such systems, you will do reliability testing from minus 40 to plus 125 or plus 150 for the components of the board that is built for automobile electronics. Therefore, before it is sent to the industry and made in large volumes and they will undergo a lot of thermal cycling to classify the board as a reliable one. So, there may be several subsystems of this type in the automobile product. Therefore, you have to make sure that they function for a large number of years. In the industry, people look for high reliability products and that is more in automobile electronics. Need to maintain stringent emission regulations. These are outside the purvey of electronics, but at the same time, your mechanism in working of the fuel injection controller and other sub systems will have a direct reflection on the measurements that is done for emission and so on. Obviously, fuel is the first important thing, to have a clean fuel. Therefore, a clean emission, but the electronics also plays a great part in monitoring these activities or figures. These regulations differ from one country to another.

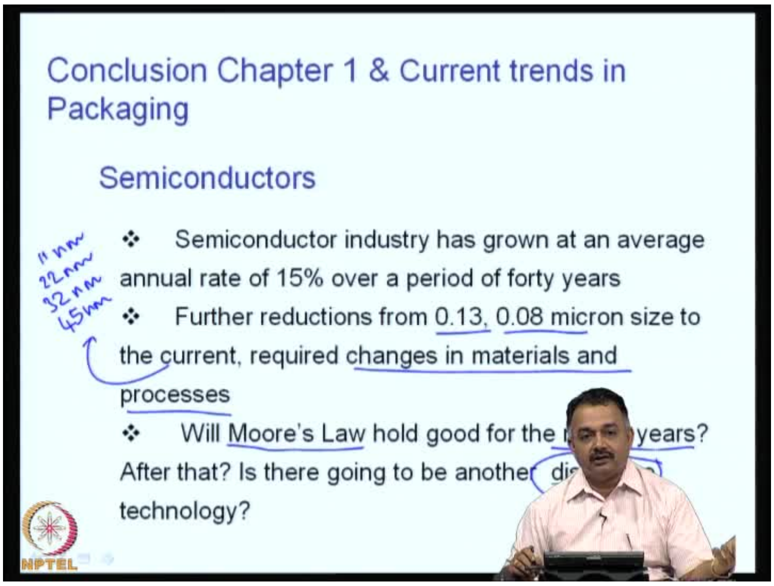
(Refer Slide Time: 13:49)



This is the conclusion of third example for product packaging. So, we have seen mobile application, low cost PC's, automobile electronics and so on. We can take different products and try to list areas or points that need to be looked at from the designers, design engineer perspective, so that you can make a reliable product. So, I think you can take the reference books from now on and look at other examples. The examples can be in the area of a medical electronics and health care. So, probably, if you take the text book of Rao Tummala and look at chapter 3. You will get such a simple case study for medical electronics. Kindly go through that and you will see what are the important implications of packaging are in medical electronics.

So, as a conclusion to chapter 1, What I will now do is give some current trends in packaging upfront, instead of talking about current trends at the end of the total package of this video course. I would like to sensitize you to the current trends in packaging up front. So that you can expect these things, to be discussed in this course from now on.

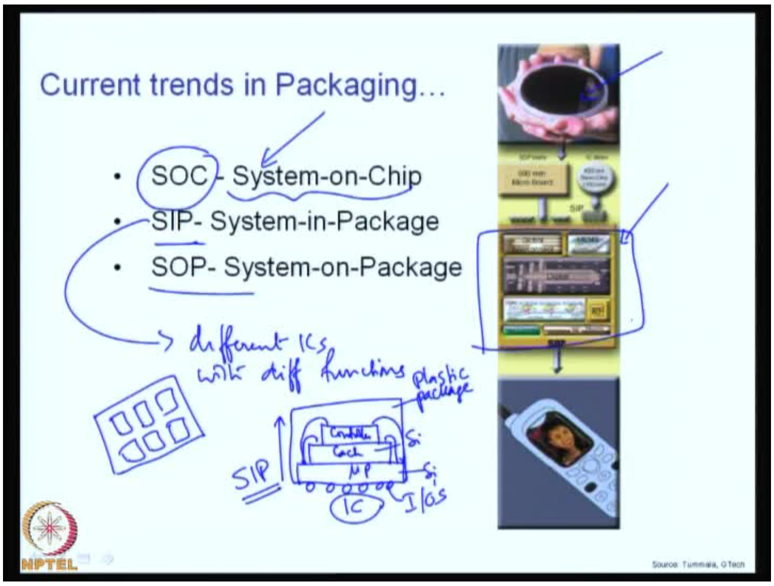
(Refer Slide Time: 15:26)



We have seen semiconductors and we have seen semiconductor industry growing at an average annual rate of 15 percent over the period of 40 years. The growth rate is constant. Further, reductions from 0.13 micron technology, 0.08 micron technology to the current. I hope you can remember what is the current technology used. We are working at 45 nanometers and 32 nanometers. These technologies are being used by companies like Intel and so on. So, all of these changes from previous higher line widths to the current line width of 32. The future is going to be 22 nanometers and also probably 11 nanometers in about 4 to 5 years from now. All of these require changes in materials and processes. I hope you can appreciate this because without new material, you cannot improve the properties of the devices or the semiconductor. So, the existing semiconductors have some limitations. So, you have to look at new compound semiconductors and so on. At the same time, existing semiconductors can work very well to create lower line widths, but the equipments related to photolithography and design imprint on the surface of the semiconductors requires a lot of technological changes, which is what we are witnessing right now.

I have explained in detail, what is Moore’s law. Now, the question is- as a conclusion to this chapter, will it hold good for the next 5 years? That means will the doubling of transistors take place every 18 months or at maximum 24 months. This is what we are going to see. If there is going to be a disruption in technology or if there is going to be a limitation post by the photolithography or imaging technique, which I think is a major bottle neck in the semiconductor industry. Then the Moore's law might not hold good in the sense that the doubling of transistors might exceed 24 months, but we are going to witness a lot of technological changes. So, is there going to be another disruptive technology? I use the word disruptive. If you can see here in the slide: disruptive technology. Why do I say disruptive? Because a new technology has to come revolutionize the imaging process, so that can be disruptive in the sense that entire process can take a new look. It can be beneficial for the semiconductor industry.

(Refer Slide Time: 18:32)



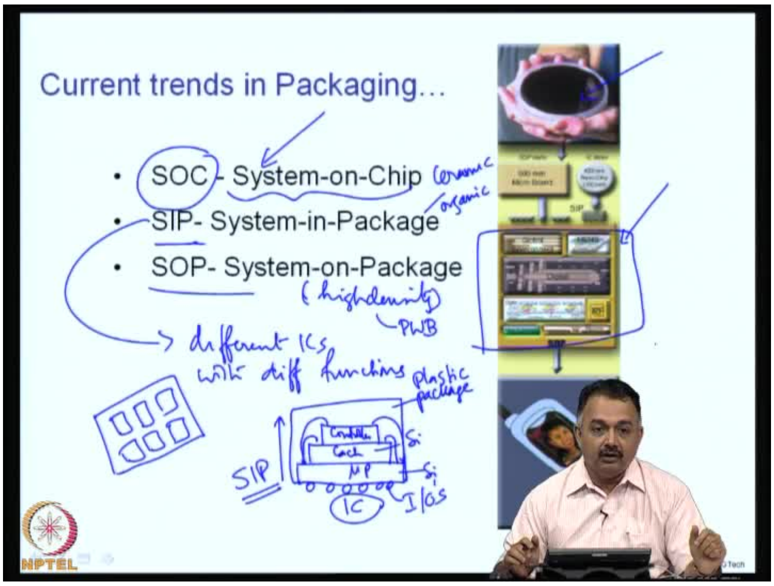
The current trends in packaging is continued. I want you to remember some of the terms. Now, I hope most of you would have heard of the term System on Chip. This is more prevalent in the semiconductor manufacturing and that means you are packing an entire system function on a single chip. So, instead of using 2 or 3 different chips for different functionalities or due to limitations in manufacturing process because of current technological changes, you are able to integrate or increase the density or packaging efficiency at the chip level. The entire interconnections of such a system can be called a System on Chip or SOC. So, if you look at this (Refer Slide Time: 19:28) figure, it will take place at the chip level.

Now, let me introduce another term called System in Package. How do you define? what do you mean by System in Package? So, if you look at a figure here (Refer Slide Time: 19:47). You can see that there can be different ICs. An IC can perform the… It can be a MEMS IC, Ram, cache, memory. This particular System in Package can house different ICs with different functions. Now, all you do is you can outsource or buy these different active devices and then package them together. For example, a simple figure (Refer Slide Time: 20:35). You have a simple IC here. Now, you take another IC and both are silicon. Now, we are going to place this silicon on this first silicon device and interconnect it. So, this can be. For example, cache, this can be microprocessor. Now, you take another device, this is again placed on same substrate and it is integrated vertically. Now, this can perform different system function. For example, it can be some other controller, card controller chip. Now, this is again connected to the first substrate and first device. Now, the entire thing can be packaged, this is your package and this can be a plastic package.

So, this now becomes a custom built IC. This is called System in Package. A system in package will perform or it is a result of bringing in 2 or more dies together and interconnecting them. The entire set of dies are housed on the same substrate. So, this is different from the multichip module concept that we have seen in a multichip module. By textbook definition, the dies are placed on the same substrate on the same plane, but here it is more or less built one on top of the other. So, this reduces space and this utilizes the entire area under the bottom die for providing your IO's. This can be manufactured only by companies that are well versed in creating System in Package because the first level interconnections for system in package are going to be very crucial in determining the reliability of the product.

In the third term, we will get a chance to discuss System in Package much more. So, as an introduction, I think this information is enough right now. When we come to System on Package, if you look at this figure here, by definition, a System on Package means, you take a printed wiring board and that will be the substrate. An organic substrate can be the substrate for the System on Package.

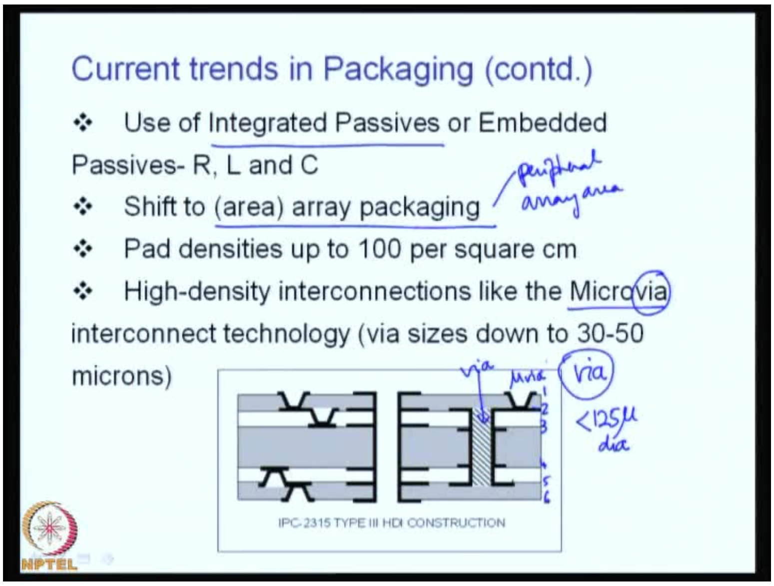
(Refer Slide Time: 18:32)



Now, you can integrate your MEMS device, your optoelectronics device, your RF device. You can have multilayer interconnections using copper. Each of these multilayer can be connected by microvias, very small via structures, which will connect the various conductors. You can embed passive into the layers of the substrate. So, this becomes a high-density package and a high density interconnect system and this is on a PWB. Typically,here, you can use ceramic or organic substrates. So, if you look at SOC, SIP, SOP, an SOP can sit on a System in Package configuration. SIP can become or be part of a module that can sit or mounted on a System on Package.

Today, the most current and advance technology is a System on Package. So, as I said before, we are going to get opportunity in the third module to discuss about packages. At that point of time I will be giving you complete information about each of this System in Package on System on Package.

(Refer Slide Time: 24:38)

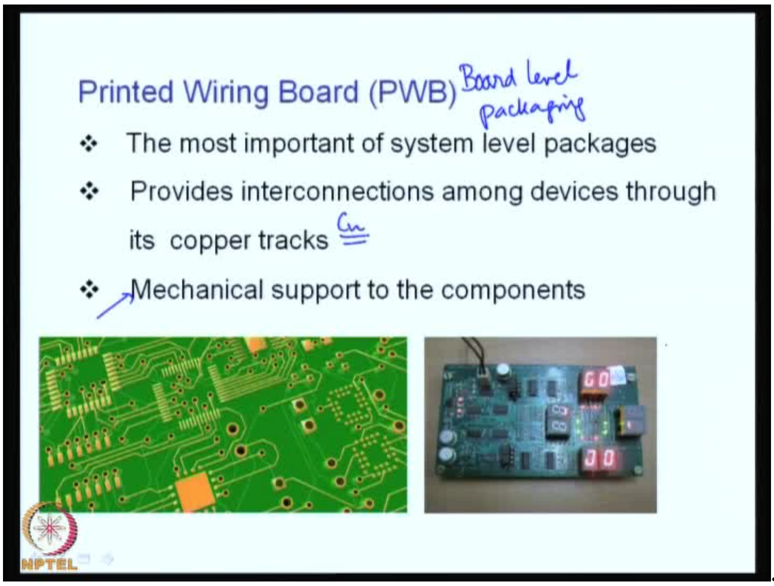


Continuing with the current trends and packaging: if you want to increase the density of your boards or your systems, as board is equal to a system today, because board performs system level functions. You have to use integrated passives rather than using bulky devices like a resistor, capacitor mounting on the board. So, you can actually build the embedded passives inside the layer.

Now as a design engineer, look into shifting to area array packaging. I think I mention to you about peripheral and area array packaging. So, you have to move away from peripheral array package in to area array packaging to get high densities. Pad densities are up to 100 pads or pins per square centimeter. High-density interconnections like the microvia interconnect technology. Now, what is a via and what is a microvia? See, if you take a printed circuit board. For example, I am showing you this board (Refer Slide Time: 25:55). This board can be built with different layers of copper wiring on the top surface. Here, you have a single layer of copper and on the other side, you see another copper or other conductor wiring. Now, you have to interconnect from top to the bottom. How do you do that? You have to create a mechanical hole and then make it conductive. So that conductive hole is called a via. When I say microvia, by definition, in any via that is less than 125 microns in diameter or above can be called as simple via structure.

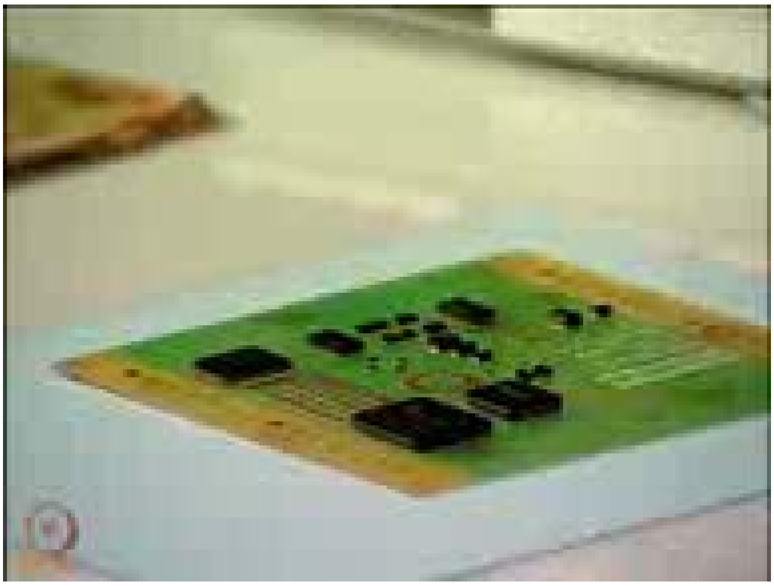
A microvia interconnect technology is now used in printed circuit boards. It has dimensions less than 125 micron and so you can imagine the size. So, this is very clearly given here in this figure. In this slide, you can see here, for example, 1, 2, 3, 4, 5, 6 layer copper wiring. You can see here, a via that is basically interconnecting copper 2 to copper 5 and there is a via that connects copper 1 to copper 2. So, this is a via and this we call as microvia because it is a very small size. Such vias are used in the semiconductor industry and also at the silicon buildup, the same technology is being used at the printed circuit board level. So, there is always a very good similarity between semiconductor manufacturing and PCB manufacturing, which as we go along, you will definitely be able to visualize and appreciate.

(Refer Slide Time: 27:58)



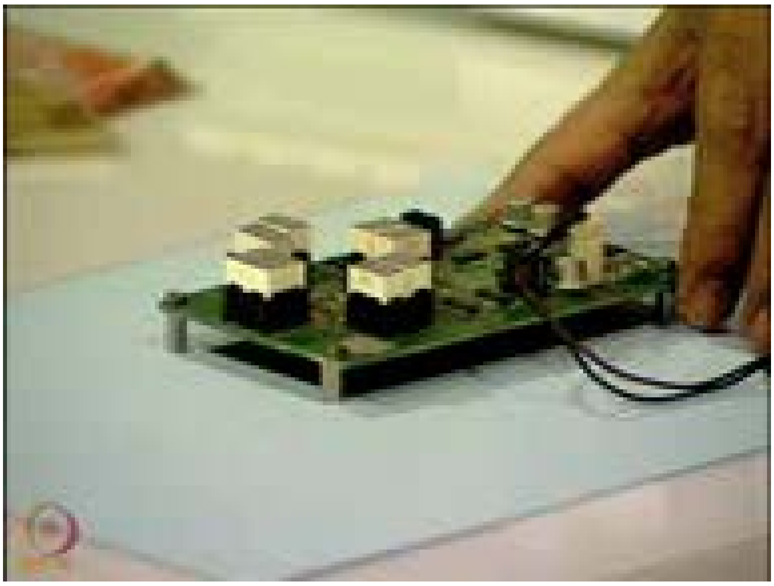
Now, look at the printed wiring board. I want to spend a few minutes here on the printed wiring board. It is the most important of system level packages. So, we can call this as board level packaging. It provides interconnections between devices. It can be an active device or a passive device through the copper tracks. So, the basic conductor used in this industry is copper. Copper is the best conductor, but we will see when we come to PWB technologies chapter. Apart from copper, the basic copper structure is built or strengthened by other conductor devices to enable soldering or attachment. The important thing is- it provides a good mechanical support to the components.

(Refer Slide Time: 29:07)



You can see in the figure or in the sample here, which I am showing right now is a printed circuit board. You can see various devices and all of them are surface mount. You can also see very tiny devices and these are all the resistors, capacitors and are in very small size. To handle these, you require equipment to pick, place and attach it on to the board. I will quickly show some other examples of PCB’s.

(Refer Slide Time: 29:32)

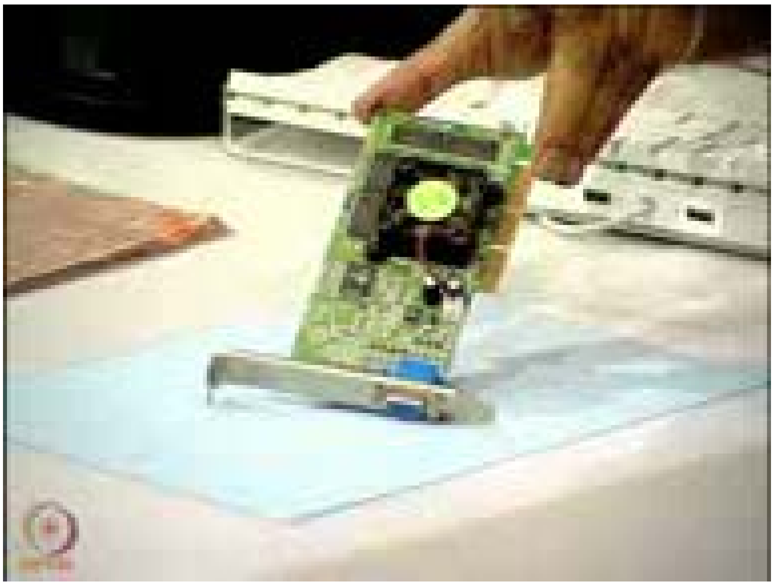


This is another printed circuit board, which is again mounted. You can see a lot of active devices, lot of displays on the board. So, this is also an organic substrate.

(Refer Slide Time: 29:47)

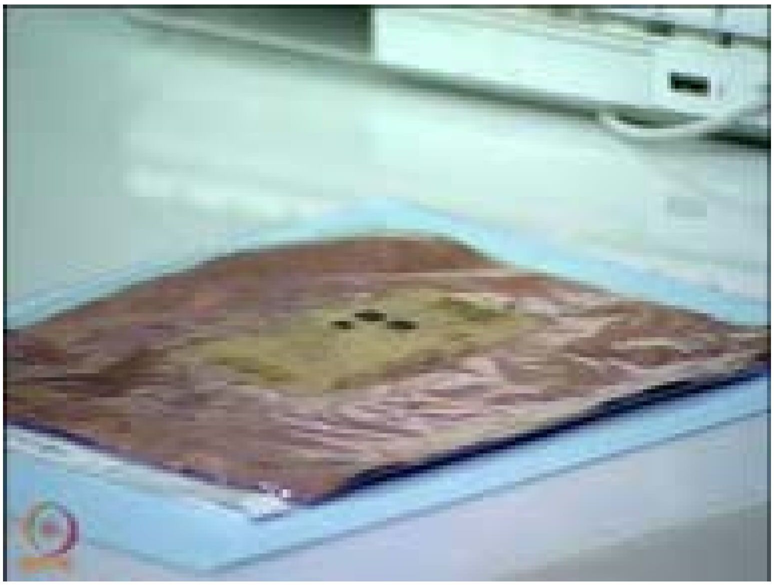
If you look at this board, you will see that this contains gold finish. You can see the glitter is from gold. So, the copper is now over plated with gold. So, there are specific reasons, why we plate gold and what is the thickness should be for the gold plating and so on. So, you can expect these technologies to be discussed in our class. So, this is the special board, which contain microvias and gold plating. If you look at your telephone membrane switches, the key pads for telephone switches are plated with gold. So, this is another board which contains a gold finish. (Refer Slide Time: 30:30).

(Refer Slide Time: 30:37)



Now, I will show you another board. You can see this board contains electro mechanical components like your fan. It means just right under the fan, there is an active device, which will be dissipating lot of heat. Therefore, as a precaution, this fan is mounted on the top of the device. So, when the board is powered up naturally, the heat will be dissipated. You can see that the heat is removed from the device as quickly as possible because if the device is heated up, then there is a very good chance of the die cracking and the substrate because it is organic in nature. It can warp and it can also melt.

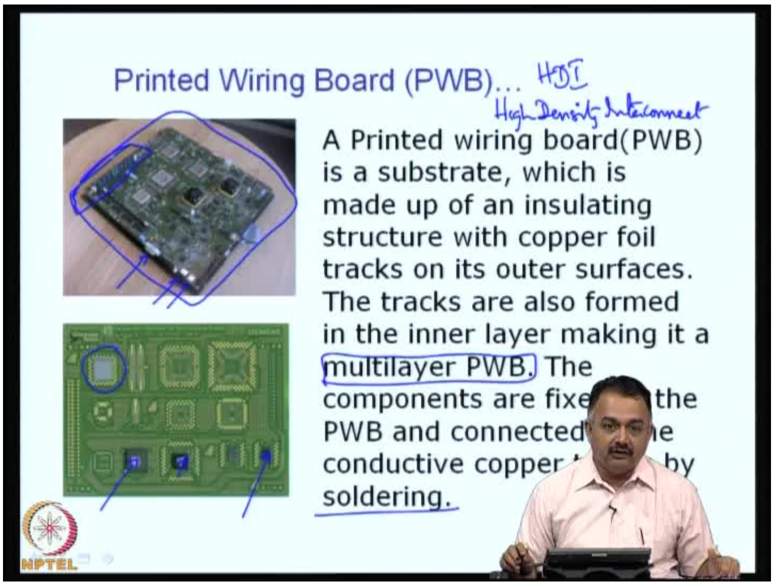
(Refer Slide Time: 31:30)



Now, I want to show you another example, a building block of a printed wired board. Now, this is a material that you are seeing here, which is the dielectric material that used in the building of the printed wiring board. This is made out of glass plus an organic resin. Now, on top of this, a copper foil like this will be laminated on to the base dielectric material to give a rigid board like this.

You can expect these technologies to be discussed in our class. We are going to spend more time in understanding how a PCB or an organic substrate or a ceramic substrate can perform system functions. So, printed wiring boards are in some sense the heart of the product. In today's electronic products, a lot of integration goes in making printed wiring board as a system level product.

(Refer Slide Time: 32:35)

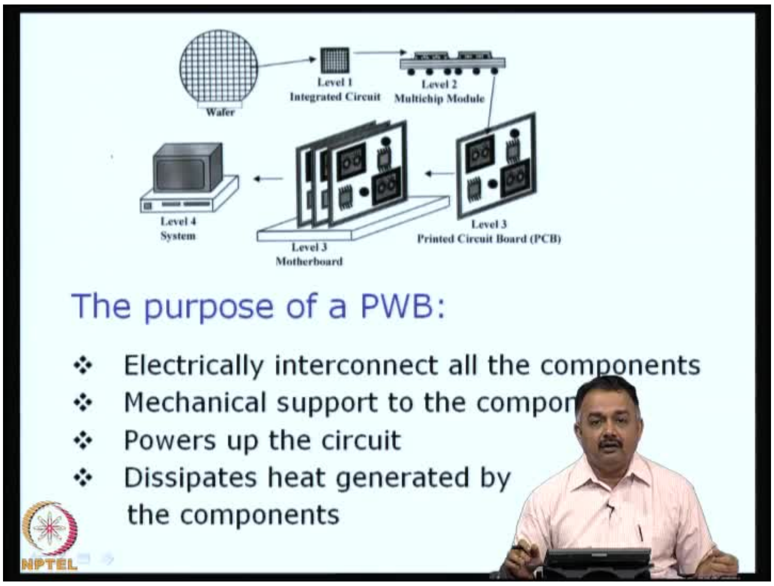


What is the printed wiring board? A printed wiring board is a substrate, which is made up of insulating structure that I showed you as an example with copper foil tracks on its outer surface. The tracks are also formed in the inner layers. I mentioned that you can make multilayers. So, the tracks need not be on the top. In the bottom, there will be inner layer, which connects to the top and bottom copper layers making it a multilayer printed wiring board with very high density.

In today's parlance, this printed wiring board is also known as High Density Interconnect substrates or HDI. Now, this printed wiring board on top of this and so the components are fixed to the top and bottom of the substrate. The components are fixed to the printed wiring board and connected to the copper traces or tracks by a process known as soldering. Soldering is the process of attaching your components to the printed wiring board or the substrate.

In this figure, (Refer Slide Time: 33:51) you can see devices are mounted on top of the printed wiring board. This is a bare die and this is a packaged die. In the top figure, you can see a very high density substrate. It has got different types of components like bare die, encapsulated die, various passive devices. You can see various connectors used at the periphery of the device. There are some relay types of components, which are mounted at the edges. So, you can have access to repair these devices during the working of a product. So, this is the basic definition of your printed wiring board. I hope you can go through it once again.

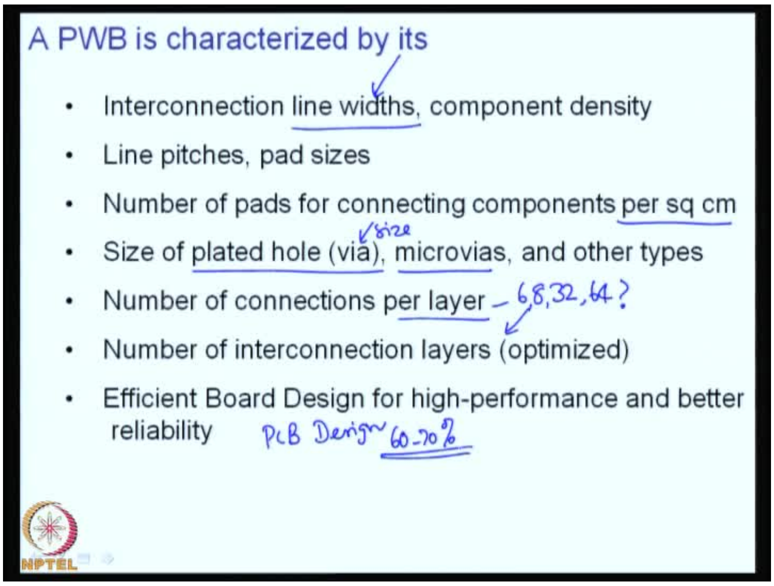
(Refer Slide Time: 34:38)



The purpose of a printed wiring board will be to electrically interconnect all the components, mechanical support to the components, powering up the circuit and it also dissipates heat generated by the components. So, naturally, you can expect the dielectric material used for the printed wiring board to be somewhat thermally conductive and remove heat to the atmosphere. You can also improve the thermal performance by adding heat sinks.

I showed you the other day, an example of a heat sink. You can use a heat sink on top of the component or you use a fan. Various other methods of cooling are now available. So, if you look at the figure here, from wafer to multichip module to board motherboard and to system.

(Refer Slide Time: 35:31)



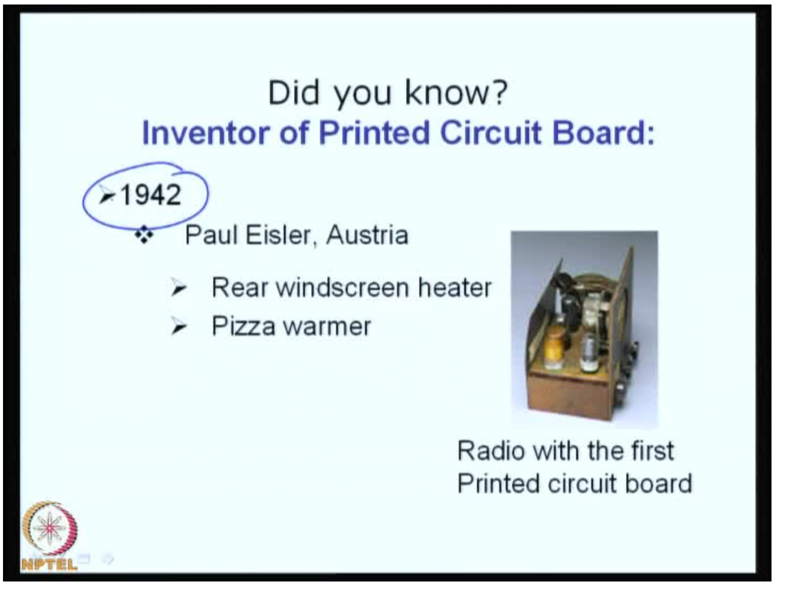
A PWB should be characterized by interconnection line widths. As we are worried about line widths in semiconductor technology, here also we are worried about how much low line widths we can go to, so that you can make it a very high density using very small space. We do not want bulky printed wiring boards to house your products and that is one of the reasons our components that is I mean the products are shrinking today. If your printed circuit board is going to be huge, then you have to build a mechanical enclosure to suit the size of the printed wiring board.

We are worried about component density, line pitches and pad sizes. Number of pads for connecting various components per square centimeter gives you the component density or the pad density, the size of the plated hole or the via. I talked to you briefly about the via or the hole. So, here again just as the interconnection line width, here also we should be worried about the size of the via. You cannot have a very large hole to interconnect layer 1 copper to layer 2 copper because that will occupy too much of space. At the same time, you are adding more copper than required. So, you should have minimum copper on the board that can perform your system function as electrically reliable system function.

Do we need microvias? What are the methods to create microvias, other technologies, and number of connections per layer? So, how many layers can you have? 6 layers, 8 layers, 32 layers, 64 layers. We are going to see that number of interconnection layers has to be optimized for efficient board design, high performance and better reliability.

I can tell you for sure that any product, if you are doing a PCB design, just as VLSI. Engineers have spent a lot of time on the VLSI cad. The PCB design engineers will spend almost 60 to 70 percent of the product life in product planning time because the rest 30 percent can easily be done by fabricating the PCB, assembling and testing it. The design takes lot of time. You have to first test it, simulate it. You can probably do some electrical modeling and then all the corrections will have to be taken back to the schematic. Iterations have to be done until you get a very good electrical performance. So, PWB design will take a lot of design time in the industry.

(Refer Slide Time: 38:25)

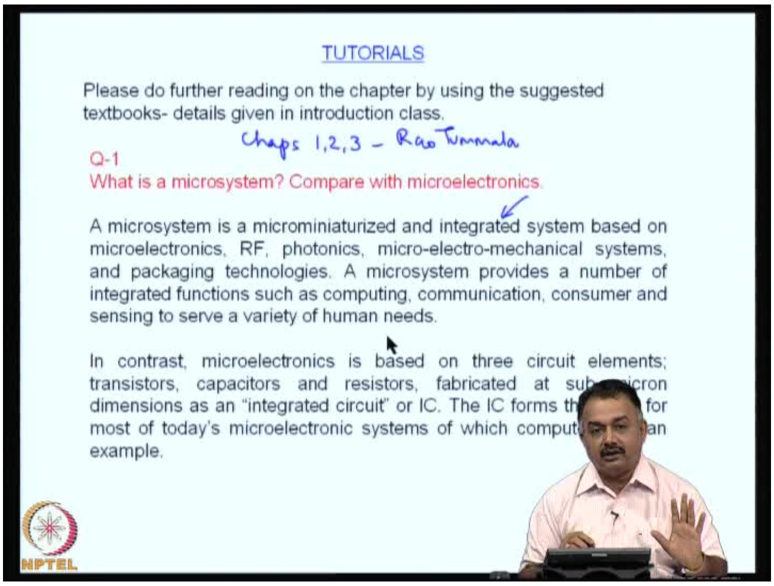


Printed circuit board or printed wiring board was incidentally discovered in 1942 by Paul Eisler of Austria. So, he was using some kind of a organic resin and he accidentally was trying to image it. Then he found that he was able to transfer the patterns using natural sunlight. Use of some die could change the color of the organic resin. So that is how patterns were transferred. We got very good products as a result of this finding.

After describing briefly about printed circuit boards or printed wiring boards, I will conclude this chapter. As I mentioned earlier, printed circuit boards and printed wiring boards will be dealt exhaustively in the future chapters. So, this is a good time for sensitizing you that is at the end of chapter 1. What you can expect in the coming chapters. So, chapter 1 will end here.

I thought I will give some tutorial. In this tutorial, I will basically put some questions for you and also try to discuss the answers, so that you will get very good conclusion or a summary from this entire episode. Next chapter will be on semiconductor packaging. We have seen semiconductors and we will briefly, what semiconductor fabrication would mean, what are the intricacies involved in semiconductor fabrication. We will have a look at the overview of the process.

(Refer Slide Time: 40:24)

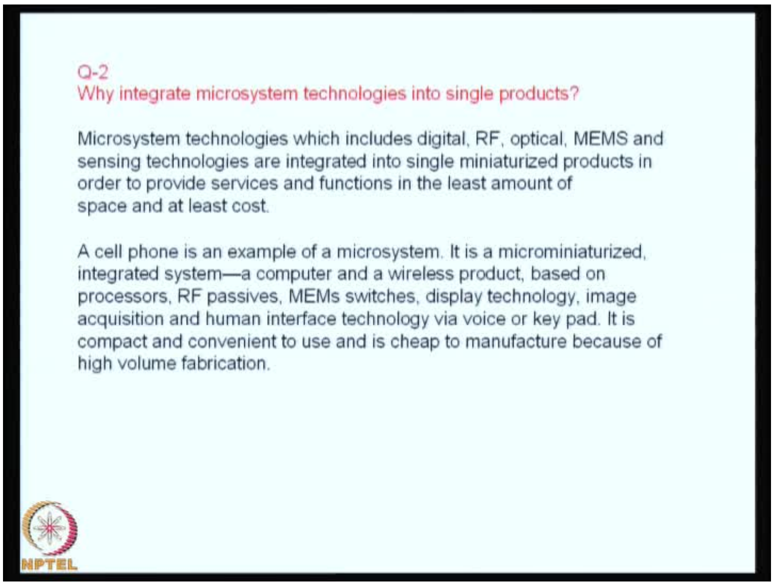


Please do some reading on this chapter 1 by using the suggested text books given to you. In the first introduction class, as I said, even if you can read chapters 1, 2, 3 of Rao Tummala, which is the prescribed text book for this course. You will be complete in your understanding about the basic packaging fundamentals.

Now, I will begin the tutorial. My first question is- what is a microsystem? We have talked about systems like micro system, nano system and so on. So, what is a microsystem and how does it compare with microelectronics? So, the two important things I am going to ask, what is microelectronics? What area it comes under and what is a microsystem? So, I will discuss the answer with you. A microsystem is a microminiaturized and integrated system based on microelectronics, RF photonics, micro electro mechanical systems and packaging technologies. So, the word integration comes here and it has to be integrated. A microsystem provides a number of integrated functions, such as computing, communication, consumer and sensing to serve a variety of human needs. So, you can see that the word integration is very important and integration can happen only if you can do or use new packaging technologies. So, a microsystem is synonymous with new packaging technologies and packaged products. In contrast, the microelectronics is based on three circuit elements; transistors, capacitors and resistors fabricated at submicron dimensions as an integrated circuit or IC. So, microelectronics would most probably cover all the aspects of a active device or a integrated circuit. The IC forms the bases for most of today's microelectronic systems and out of which computer is a chief example.

I think you are very clear right now. What is the difference with microelectronics and a microsystem? Microsystems, will include a lot of microelectronics. It is based on microelectronics and out of which, the various application areas will be RF photonics, MEMS, MOEMS, various other optoelectrical systems and so on. So, please remember the terms microelectronics and microsystem.

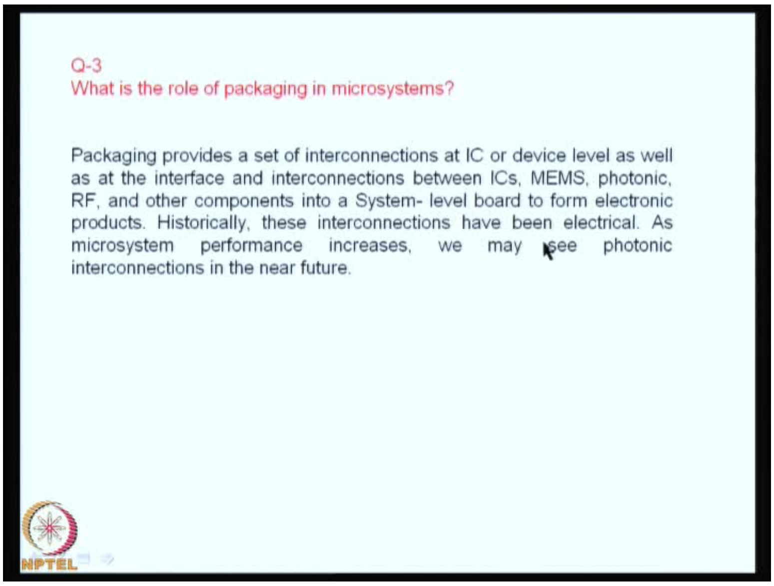
(Refer Slide Time: 43:25)



The next question that I am asking you is- why integrate microsystem technologies into single products? What is the need for having single products? Does it affect the size? Does it affect performance? So, microsystem technologies, which include digital RF, Optical MEMS and other sensing technologies. They are integrated into single products in order to provide services and functions in the least amount of space and cost. This is what I have been emphasizing all along. When you do a product packaging, you are indirectly doing miniaturization, although you might not be aware of it. Eventually, if you choose the best devices or best components available, you will end up with a very good single product, which is small in nature, small in size. So, you will end up with the deliverables as least amount of space occupied at the least cost.

Your packaging engineer should look into these two aspects. What is the example? A cell phone is a very good example of a microsystem. It is microminiaturized, it is integrated. It is a computer and a wireless product based on processors RF passives, MEMS, switches display technology image acquisition and human interface technology via voice or keypad. It is compact to use, convenient to use, it is cheap to manufacture because of high volume fabrication. A cell phone will have a computing processor DSP or whatever. It is a wireless product, other processors and controllers, passive devices, it has display technologies, which are current image acquisition camera and it is very small. It can immediately capture store and send globally through the network. So, all of these things are possible with the single product. So, this is a very good example of microsystem technologies being integrated in a single product. There may be different boards, which perform different functions, but at the same time they are highly integrated. What is the role of packaging in Microsystems? We have seen various set functions.

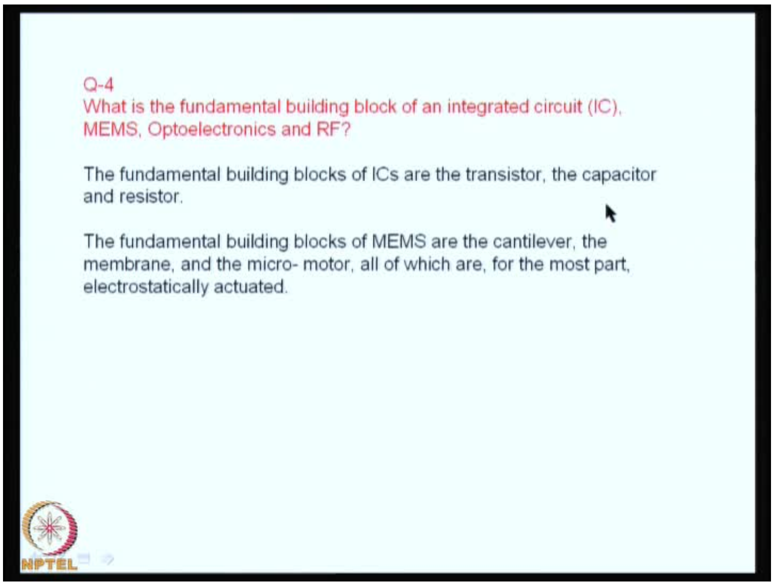
(Refer Slide Time: 46:17)



Now, let us see, what is the role of packaging? Without packaging, does microsystem mean anything? Packaging provides a set of interconnections at IC or device level as well as at the interface and interconnections between ICs, which are at the board level. So, this interconnections between ICs are actually at the board level. Then you have MEMS, photonic RF and other components into a system level board. So, here is where most of the packaging activity takes place to form electronic products. Historically, these interconnections have been electrical.

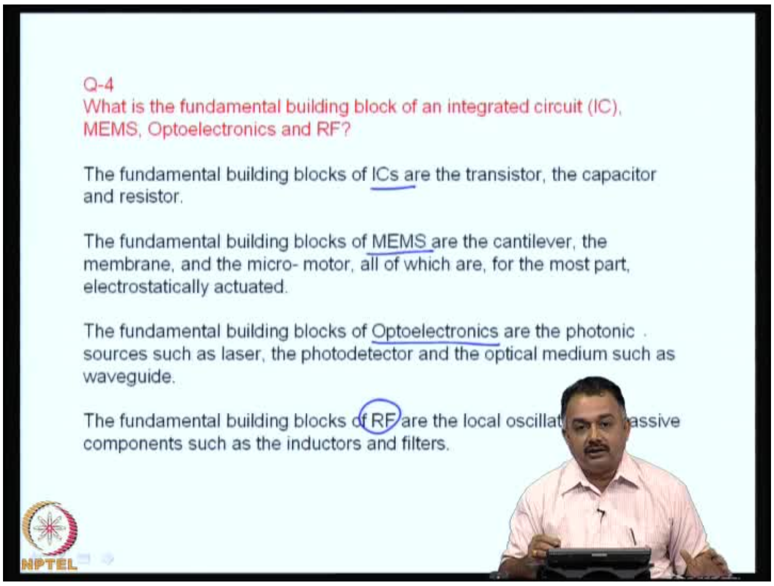
As microsystem performance increases, we may see photonic interconnections in the near future. So, the important opinion that we should gather from this chapter 1 is that System level boards perform system functions. For that to happen, packaging is very important because you are using various devices like ICs, MEMS and various other components. They have to be interconnected and for that system level board packaging becomes very important.

(Refer Slide Time: 47:26)



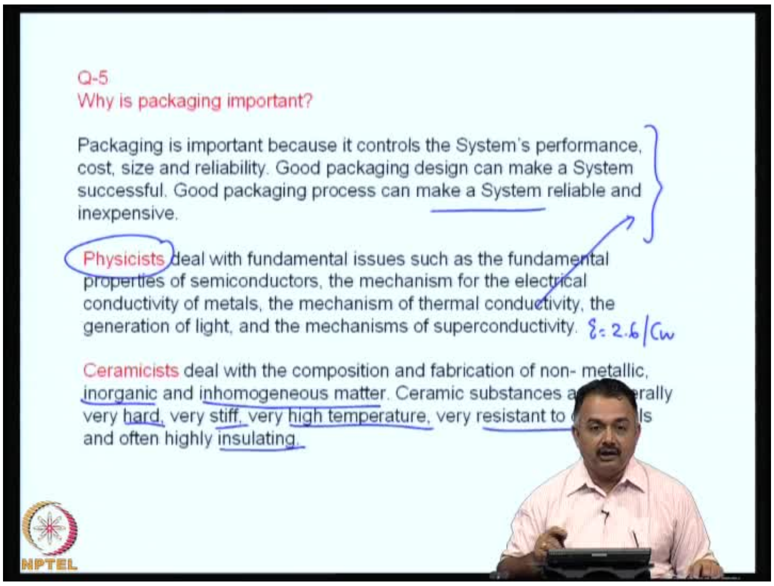
The next question is- what is the fundamental building block of an integrated circuit, MEMS, optoelectronic device and RF device? The fundamental building blocks of ICs are transistor, capacitor and a resistor. To control the performance of the transistor, you are building insitu during the fabrication of the devices like capacitors, resistors and that is how it is built and packaged. The fundamental building blocks of MEMS devices are the cantilever, the membrane, the micro motor and all of which are electrostatically actuated. We do not have a chapter on MEMS here, but we must understand and appreciate that MEMS is a result of very good system level packaging. It is a miniaturized product. The electronics may be very small in MEMS, but at the same time, it involves lot of mechanical performance and actions.

(Refer Slide Time: 48:35)



The fundamental building blocks of optoelectronic devices are the photonic sources, such as the laser, the photodetector and the optical medium such as waveguide. The fundamental building blocks of a RF are the local oscillator, the passive components, such as inductors and filters. So, for each of these, there are some fundamental building blocks and if you are aware, it will be very useful.

(Refer Slide Time: 49:10)

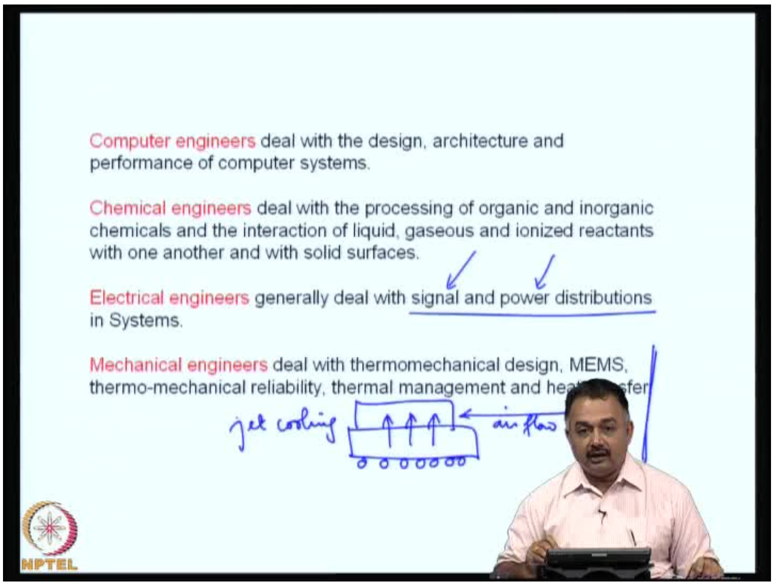


Now, again a different type of a question, we have seen in the earlier question about the role of packaging, why packaging is important. It improves the system performance and there is no doubt about it. It reduces the cost, reduces the size and increases the reliability and functionality of your product. A good packaging design can make a system successful because it can also improve avenues for understanding new materials and researching into new processes, whether it is electrical, thermal or pure material processes. Good packaging process can make a system reliable and inexpensive.

Finally, we are we understanding packaging to do this. What is that? We have to make a system that is reliable and inexpensive, whatever be the field and that is the main aim of understanding packaging. Now, I think I have mentioned about this in the area of packaging. There can be a lot of physicists working in packaging. They work with issues like semiconductor properties, the mechanism for electrical conductivity, thermal conductivity of materials are very important in packaging today. Because, if you want to use a material with the dielectric constant of 2.6. Can you really find out how good it is going to be in terms of electrical performance along with copper? Whether it is going to create a lot of cross talk, noise and other parasitics associated in the electronics domain.

If you took at materials engineers, for example, the ceramicists people, who work in ceramics. They deal with the composition and fabrication of inorganic and inhomogeneous matter. If you want to use ceramic substrate instead of organic substrates, then you need to know the properties of ceramic material like hardness, stiffness, its capability to withstand high temperatures, resistance to chemical and insulating properties. These are very important from the electrical and thermal stand point.

(Refer Slide Time: 51:47)

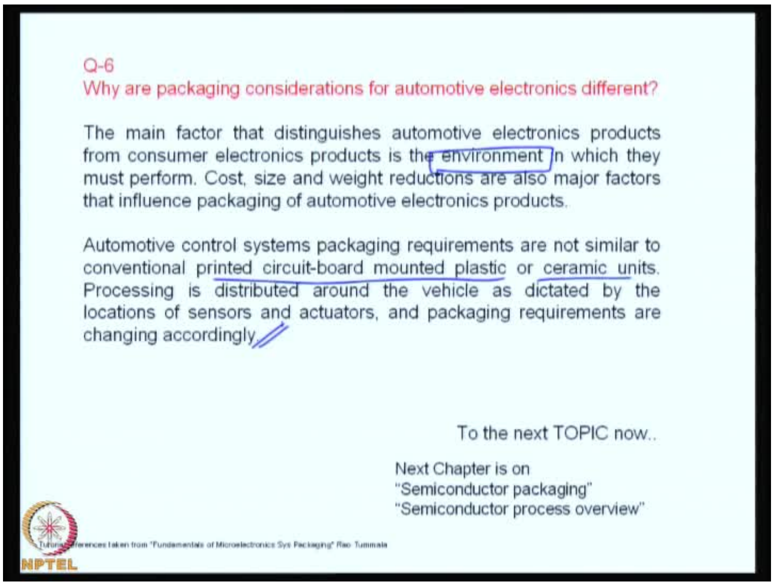


Computer engineers are of course important in building the architecture of microprocessor and other active devices. They are also important in the performance of computer systems, reliability of computer systems. Chemical engineers deal with the processing of organic and inorganic chemicals, interaction of liquid gaseous and ionized reactants with one another and with solid surfaces.

Electrical engineers deal with signal and power distribution in systems. When we looked at the definition of the packaging, I think I have emphasized about signal distribution and power distribution efficiency in a package and in a system. For that these electrical engineers should work with material engineers to get a very good reliable system. Mechanical engineers contribute to packaging and can work with thermo-mechanical design, for example, I talked about a package. Now, there is going to be lot of heat dissipated from this device. Now, mechanical engineers can really tell us what type of heat sink you can place. Whether you can use some convection based air flow mechanism or you can use a in pinched jet cooling to quickly remove the heat and so on.

Thermal management and as a result thermo-mechanical reliability, heat transfer are very important areas, where mechanical engineers can contribute in the realm of a packaging.

(Refer Slide Time: 53:28)

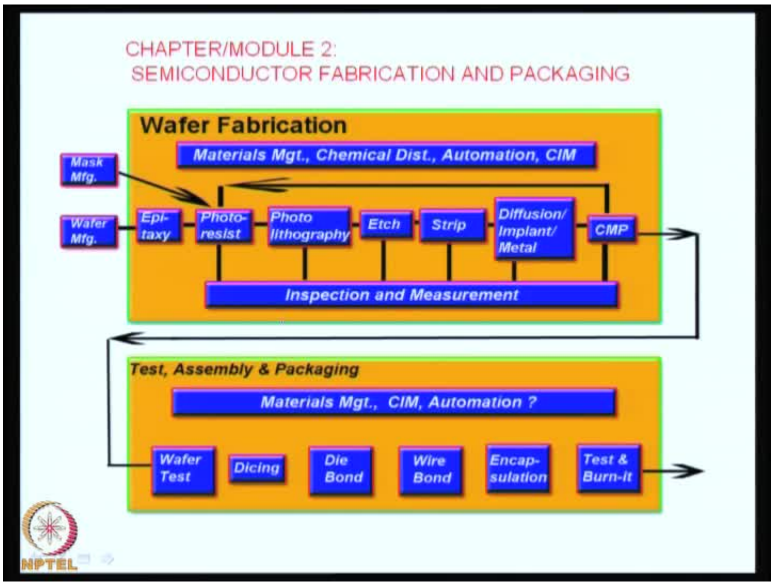


Why are packaging considerations for automotive electronics different? We have seen this during the examples in the case study. This has got a different set of conditions and requirements. The reason is the difference between this and consumer electronics is that the environment in which they perform makes the packaging activity for an automotive electronics very different and difficult. Cost, size and weight reductions are also the major factors that influence packaging of automotive electronic products.

Automotive electronic products are not similar to printed circuit board, plastic material or ceramic units, which I have shown. So, you have to make a very important decision. Can I use a plastic or a ceramic for automotive? Processing is distributed around the vehicle as dictated by locations of sensors and actuators. Packaging requirement are changing accordingly. So, it is not unique in some sense, it varies from system to system. So, with this our tutorials come to a conclusion for chapter 1. We will be looking at chapter 2 from now on. The next class will deal with semiconductor packaging and semiconductor process overview. I hope, you have got a very good glimpse about the summary and overview through these tutorials. Please go through these tutorials once again and then the chapters I mentioned. There are different textbooks apart from Rao

Tummala. You can look at R. S. Khandpur and that is also a suggestive textbook for this particular course.

(Refer Slide Time: 55:24)



In the next class, we will look at chapter 2, which is Semiconductor Fabrication and Package. This is our starting point for the next chapter. Thank you so much and we will meet in the next class.