Lecture – 01

Introduction to Op-amp

Hi welcome to this particular lecture and the as you know the course is focused on developing electronic models for industrial application, using what using operational amplifiers. This course is then kind of extension to the earlier course that was on integrated circuits, OP Amps, MOSFETs and their applications. So in that course particularly what we have seen is basics of OP Amps, basics of MOSFET and we also covered the fabrication part, how we can fabricate an indicator circuit. To be precise we understood, how to fabricate a MOSFET. Now once we have a basic idea of all this modules and all these applications, we need to move further and understand its practical applications, how to design? How to simulate? and how to implement the things that we have learned? So when you talk about operational amplifiers we need to understand, what our operational affairs? What are the specifications of an operational amplifier? and what kind of circuits we can develop using operational amplifier? And then combining various sections of those circuits will form an entire electronic module, right? So let us see what we have done in that whole course those people who have not taken, it or those people even who have taken that course, it is good for them to refresh that particular course. So this is a kind of summary of that course.

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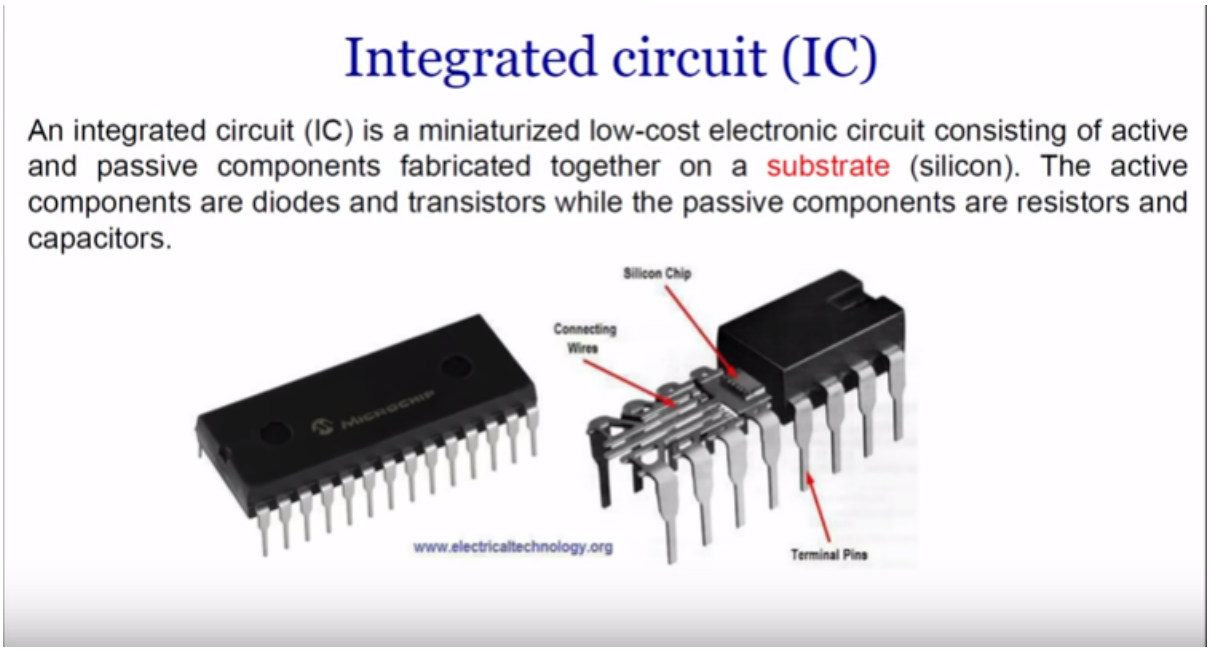

First, what exactly an integrated circuit means? Okay, so you may have already seen lot of ICs in your laboratory, but what is there within, IC? What is there within the integrated circuit? That is the idea. So when you open the casing what you find is a small silicon chip, as shown in the figure and there are connecting wires and there are terminal pins. this silicon chip consists of, lot of circuits which are fabricated in a micro Fab Lab or Nanofab lab and consists of seven thousands of transistors, whether you can say media trees or you can say MOSFETs right

and this is how, it is, it is a combination of a passive components and active components. Okay now the silicon chip that is used is called substrate and on that silicon chip, we fabricate thousands of transistors. so the active components are diodes and transistors, while the passive components are resisters or capacitors, we already know that, also there are two things that you have to understand, one is a terminal pins, which are the legs that you can see in the IC, but there are also connecting wires and there are the disconnecting wires, are connected to the silicon chip through wire bonding mechanism or through another packaging mechanism. so that is the important point that the operation of development we talked it's just a part, or assembly for IC is consisting of a silicon chip, with several thousands of MOSFETs and transistor placed in a certain way, to perform the operational you know operations several operations from summing to indicating to differentiating, with the help of the passive components.

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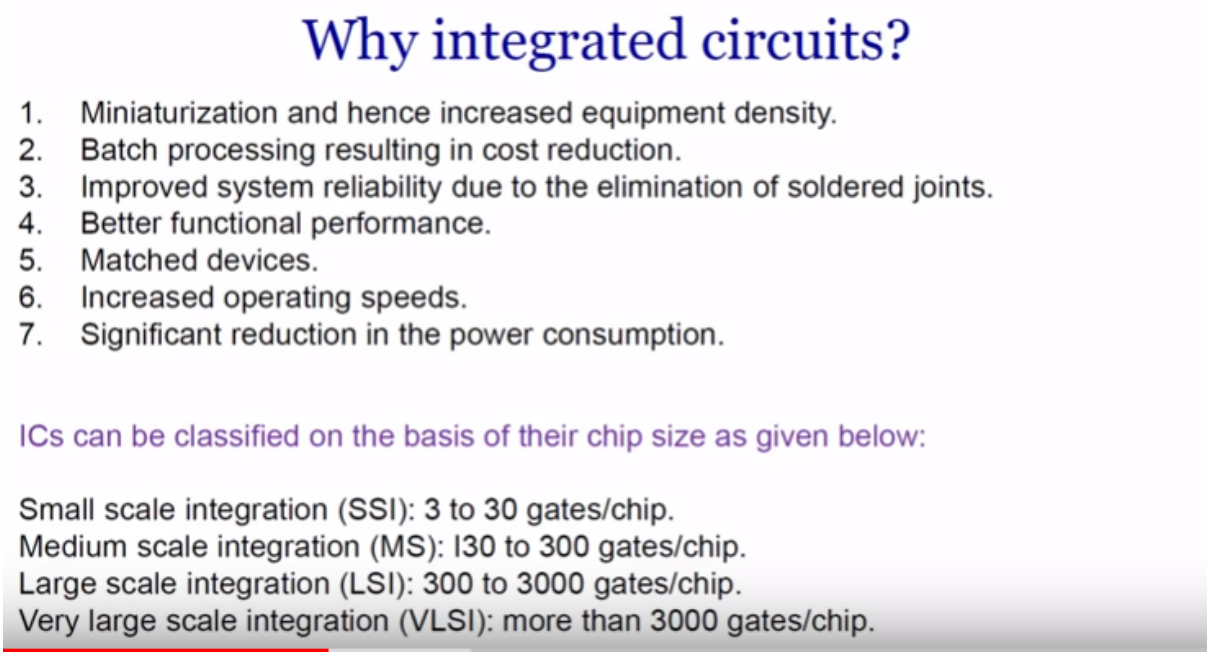

So let us see in detail then you will understand, but before we go to OP Amps in reality, we let us see, what are the integrated circuits? and why integrated circuits? First is, the advantage why you there is a miniaturization possible and hence if you have miniaturized I you know miniaturized, device then you can have increase equipment density. Second is you can have batch processing if you have best processing then there will be reduction in the cost. Third one is, if the system is more reliable because there is an elimination of solder joints. Fourth one is, that it can functional better, then it has match devices, then it can increase operating speeds and finally significant reduction in the power consumption. These are the advantages of the ICs, over discrete components and that's why there is a need of indicator circuit. Now when you talk about ICs, then how they are classified? They’re classified as small scale integration (SSI), they are classified as (MSI) medium scale integration, and they’re classified as

large-scale integration (LSI) and very large scale integration (VLSI). So when you talk about SSI, there are three to thirty gates per chip, where you talk about VLSI, it has more than three thousand gates for chip and MSI and LSI lies even between a SSI VLSI.

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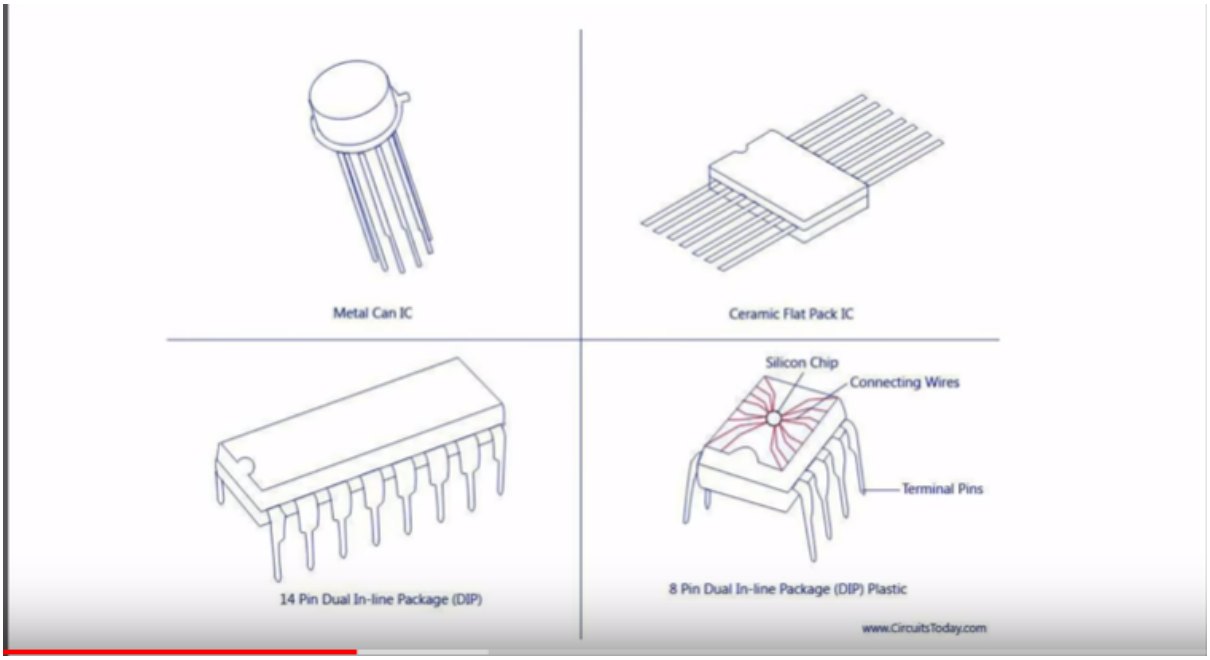

So these are a few of the schematics, where you can see metal can IC, the Ceramic flat pack IC, the 14 pin dual in-line package(DIP) and eight pin dual in-line package integrated circuits, right?

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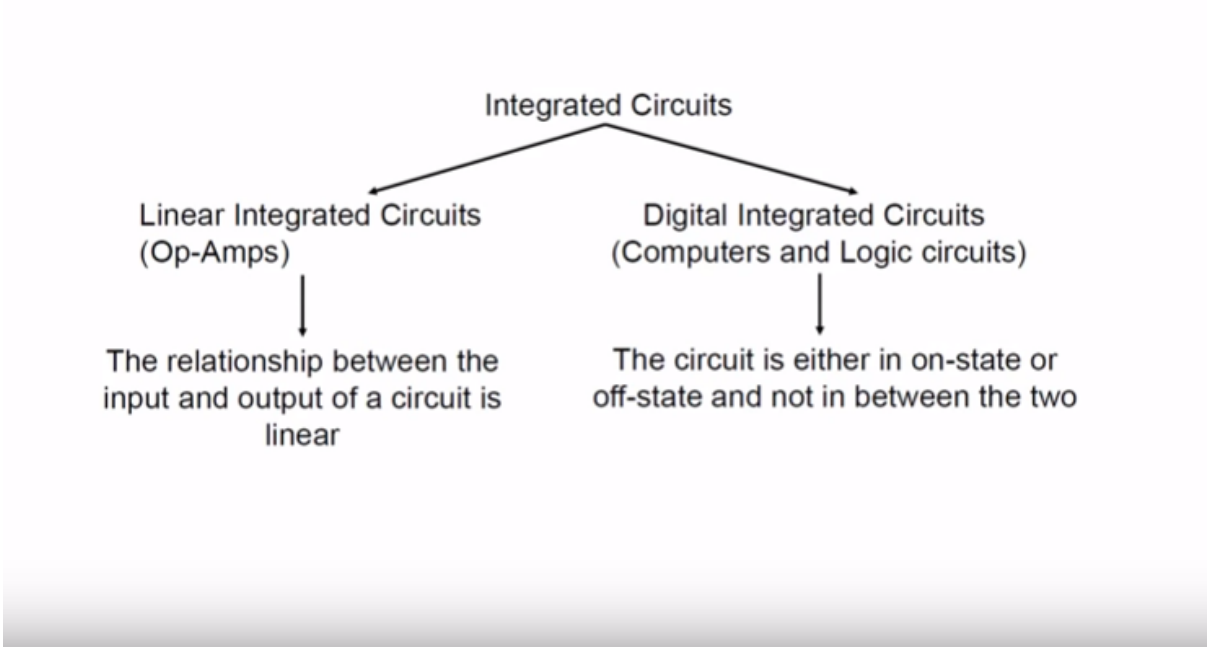

and if you go to the next slide, what you see? we see that integrated circuits can be classified into two parts, one is, linear integrated circuits, where our op-amp lies and another one is digital integrated circuits, where computer and logic circuits are used, the relation between the input and output of circuit is linear, in case of the linear integrated circuits, while in case of digital integrated circuits, the circuit is either in on state, or it's off state and not in between the two, right? so if you further understand, about the integrated circuits, what you will see that there are classes of integrated circuit. We will start with a monolithic integrated circuit. What is actually monolithic integrated circuit is? if one monolithic comes from a geek Greek word called Mono and litho, so which means, single and stone, Munoz single, lithos stone carving on a single stone, monolithic right? that's how the name has arrived and if you see the monolithic ICs, refers to a single stone or a single Crystal, right?

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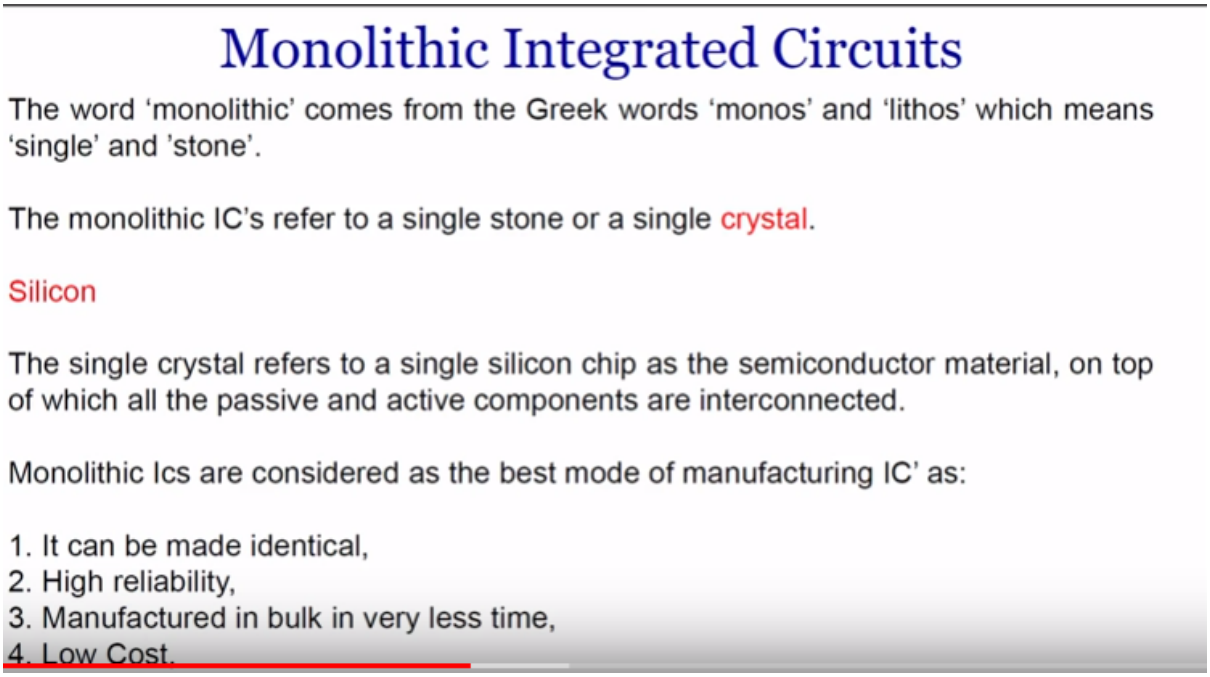

And here in our case, when you talk about the single crystal, we have to talk about silicon. This single crystal refers to a, single silicon chip, as the semiconductor material on top of which all the positive all the passive and active components are interconnected, further the monolithic ICs, are considered to be the best mode of manufacturing, why? because it the devices can be made identical, high-reliability, when you say ICs all the ICs are made identical, that's what I mean, High-reliability, manufacture in bulk and in very less time and finally it is a low cost, low cost, okay?

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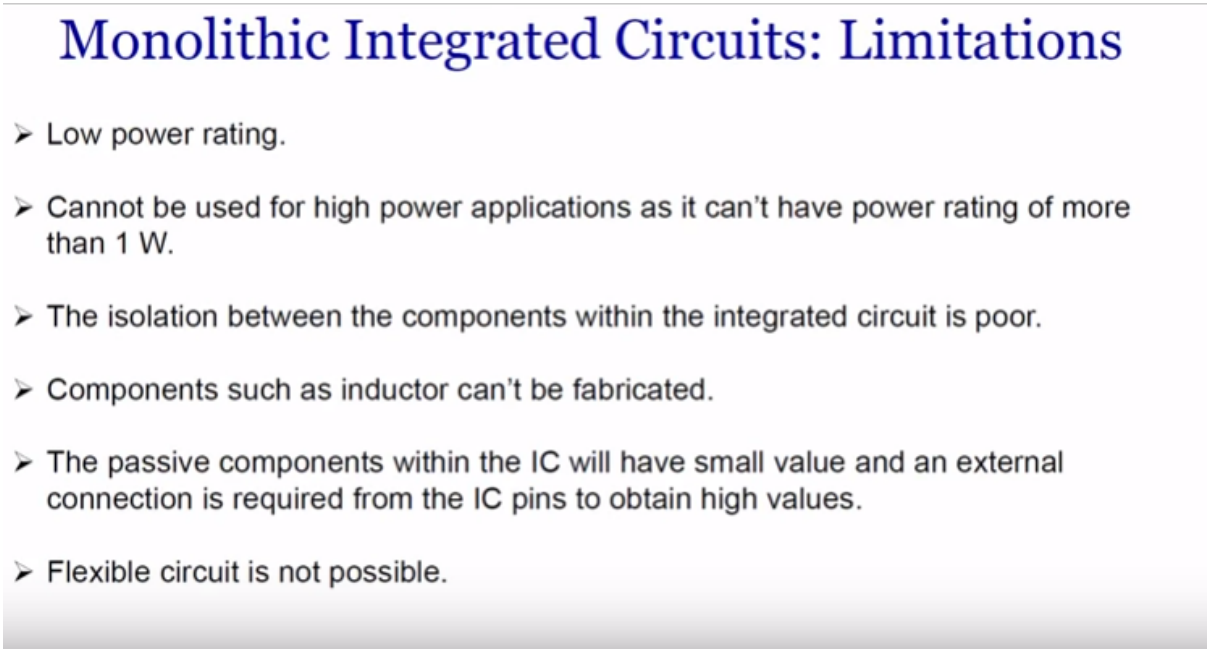

Now what if there are some advantages, what are the limitations? the limitations are that the monolithic ICs, suffers from low power rating, that it cannot be used for high power applications, it can have power rating of more than one watt, the isolation between components within Indian circuit is poor, we have component such as inductor that cannot be fabricated, the passive components within the ICs will have small value and the external connection is required from the IC pins, to obtain high values and finally flexible circuit is not possible. right? so these are a few of the limitations of the monolithic integrated circuit, right?

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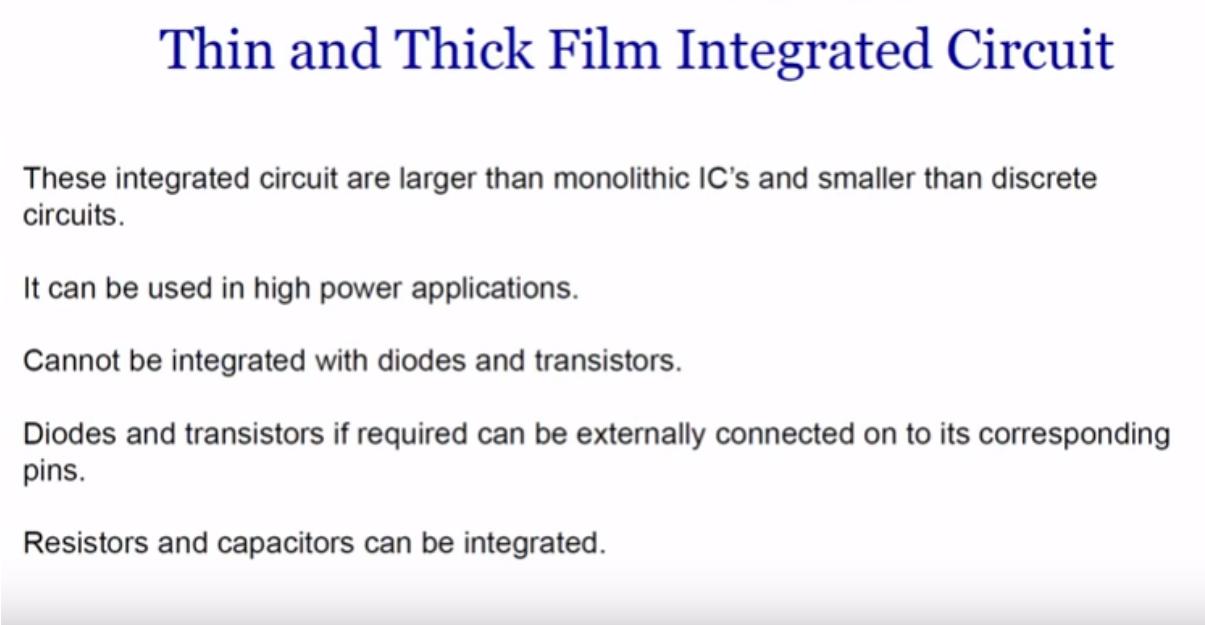

So what to do? Where to go for another two kind of ICS and there are thin and thin thick frame integrated circuits. These integrated circuits are larger, compared to monolithic ICs and smaller compared to discrete ICs, or discrete circuits, not really discredited in these circuits. Then it can be used in high-power applications, however cannot be indicated with diodes and transistors, right? Then what are the other things? diodes and transistors if we require to use with thin and thin film technologies or thick thin and thick frame indicator circuits, then we are to connect it, corresponding to its corresponding pins. Finally resistors and capacitors can be indicated when you talk about, thin and thick film technology. All right so these are some of the points where you don't understand but if I compare thin and thick film technology, then as you can see here in

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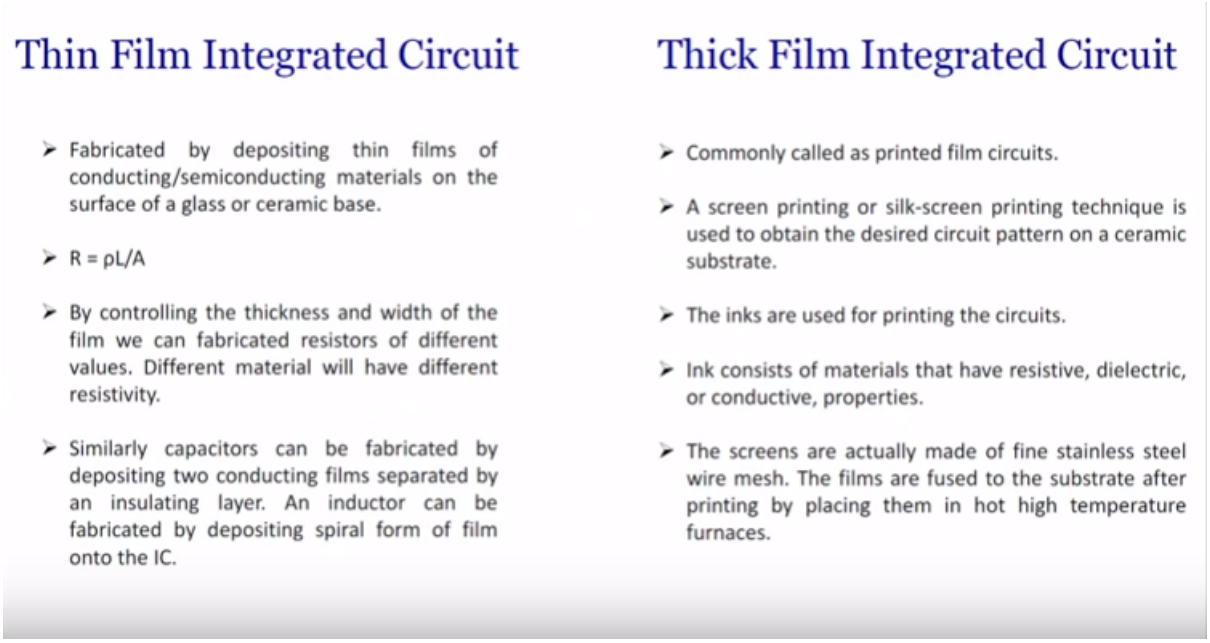

the slide the thin film circuits or integrated circuits can be fabricated using conducting material or semiconducting material, on the surface of a glass or ceramic base, the substrate can be glass, substrate can be ceramic, substrate can be semiconductor, like Silicon or germanium. Now you know that resistance value or resistance formula R equals to row L by A, what is R? Resistance row, resistivity L length, A area, right? So by controlling the thickness in the width of the film, we can fabricate resistors, of different values isn't it? A is W by T, the W into T, right? so if I change the width, or if I change the thickness then my resistance would change if my area is small, my resistance is higher, my area is high my resistance is lower, if my length is larger, my resistance is larger, well my length is lower my lower, my resistance will be lower and of course resistivity remains constant, for a given material, at a given temperature. So different material will have different resistivity and similarly capacitors can be fabricated by depositing two conducting films, separated by a insulating layer, an inductor can be fabricated by depositing spiral form of film on to the ICS. Right these are the some of the things that we need to understand. When you talk about capacitor, so how can capacitor fabricated? so if I have a metal film let's say this is my mental film, my hand, right palm and then on that if I have an insulating layer that's a silicon dioxide and then on that if I have another layer which is another metal, then these two plates, two plates, conducting plates, separated by a dielectric material, which is silicon dioxide, we can fabricate capacitor with the help of thin frame circuits. Now if you if you use lithography, I'll teach you lithography, is a part of this course, then you can also make spiral design or spiral design, which will help you to fabricate inductors, right? Using thin film technology, which was not possible in case of monolithic ICs, right? But when you talk about thin film versus, thick film, if you come, if talk about thick film, it's very easy to understand. Do you know what exactly thick film or where thick film is used? Can you guess? Did you guess right? If you if you guessed it, I cannot listen to you. So don't worry about it, but my point is when you see invitation cards, when you see the wedding cards, right? And when you see some names

printed on the cards, that is using screen printing, screen printing, right? Is the screen there's a mesh, then the ink which we use squeeze, to screen to transfer the pattern on the paper and then you dry it out, right? Screen printing technology, screen printing is used to is a part of thick film technology. if the ink is conductive or the inky semi conductive, we can develop the different kind of sensors, so easy you see. if I have a semiconducting material and if I, if I have a Interdigital electrodes, if I squeeze the semiconducting material, through the mesh, in the given pattern, I can form a sensing layer on to and interdigital electrodes which will form a case sensor. I will discuss with you in, in one of the class, how can we quickly make a case sensor, with the help of thick film integrated technology, in, in fact thin film integrated technology will also come.

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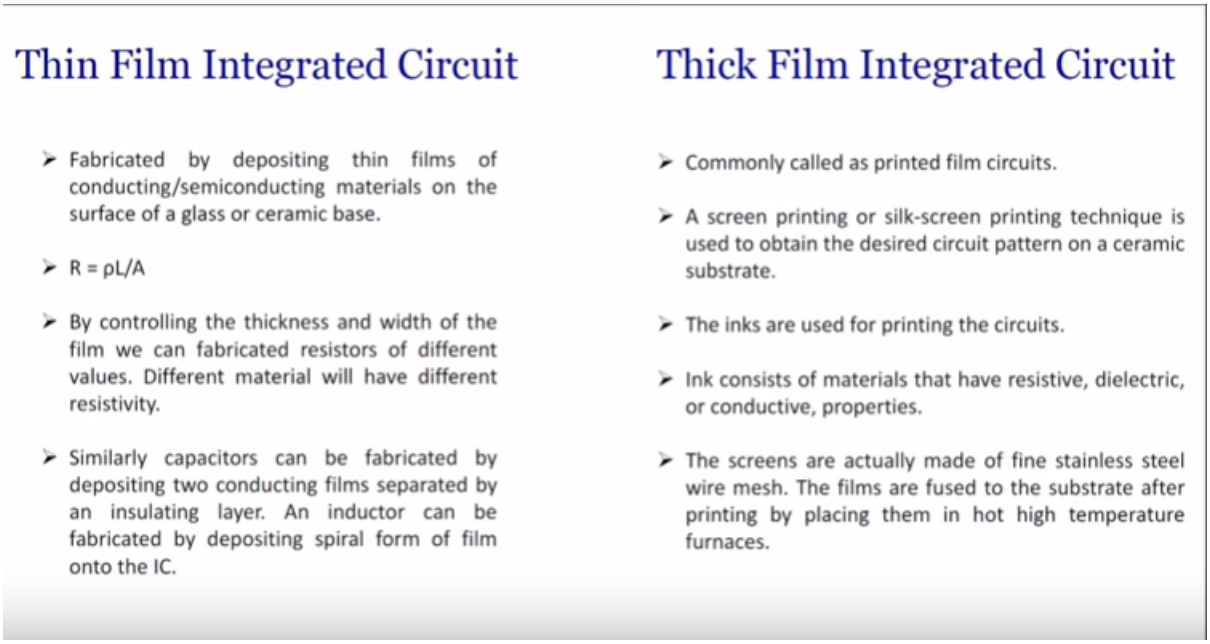

As well we'll compare it so if you see on the screen thick from technology, or thin thick film indicated circuit are also commonly called as we printed film circuits, a screen printing or silkscreen printing technique is used to obtain the screen it's a desire circuit pattern, the inks are used for printing the circuits, in consists of materials that have resistive, dielectric or conductive properties. And finally the screens are actually made up of fine stainless steel wire mesh the films are fused to substrate after printing by placing them in a hot temperature furnace, right? So thick integrated technologies are used for, for as a part of indicator circuit, right and has mentioned here the disadvantage here is that you cannot have dimensions, as small as what you can get from thin film. Thin film you can precisely get close to 3 micron, 4 micron dimensions, thick film also you can actually get it but the point is if you are using the mesh, which is a steel mesh,

the minimum feature size in the steel mesh could not be as fine as, lithography, right? It cannot be as fine as, lithography.

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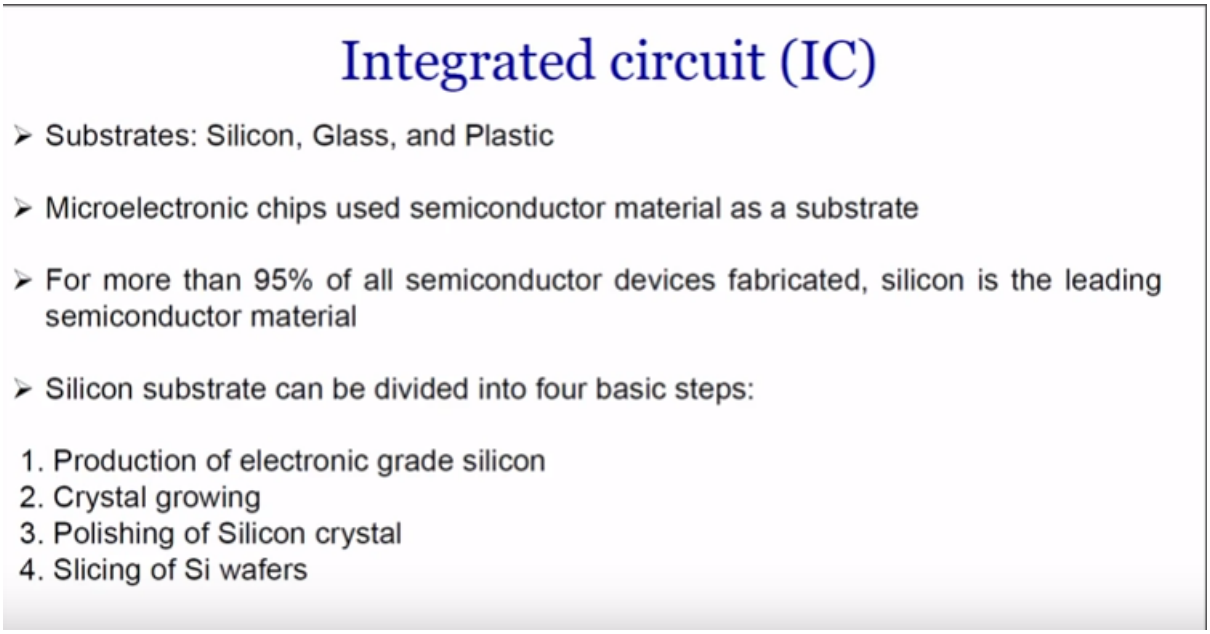

The advantages, when compared come to monolithic ICs, are better tolerance, better isolation between components and flexibility in circuit design, right? However you had to understand that this cannot be the thin and thick film IC technology, cannot be used to fabricate at the components, as it will further result in increased size. So that is the caution. Now when you talk about monolithic when you talk about thin and thick frame, how about hybrid or multi chip integrated circuits? the hybrid or multi chip integrated circuits is fabricated, by interconnecting a number of individual chips, it is used for high power audio amplifiers, diffuse transistors or diodes, if use registers or capacitors and the metalized pattern or wiring is used for interconnection between the individual chips, okay? Now if you further understand the indicator circuits the substrates that are used in integrated circuits are silicon glass and plastic you can say silicon insulator passing insulator and you can use a substrate you can use my car also you can use crystals also and with some sometimes people deposit films, so crystals are substrate, microelectronic chips use semiconducting or semiconductor material is a substrate, for more than 95% of all semiconductor devices, fabricated silicon is the leading semiconducting material. Silicon substrate can be divided into four basic steps, the steps are production of electrode grain silicon, second step is crystal growing, third step is polishing and finally slicing of silicon wafer. So we need to understand what are the techniques that are used to fabricate silicon wafers, because finally we are using silicon to fabricate the different indicated circuits, right?

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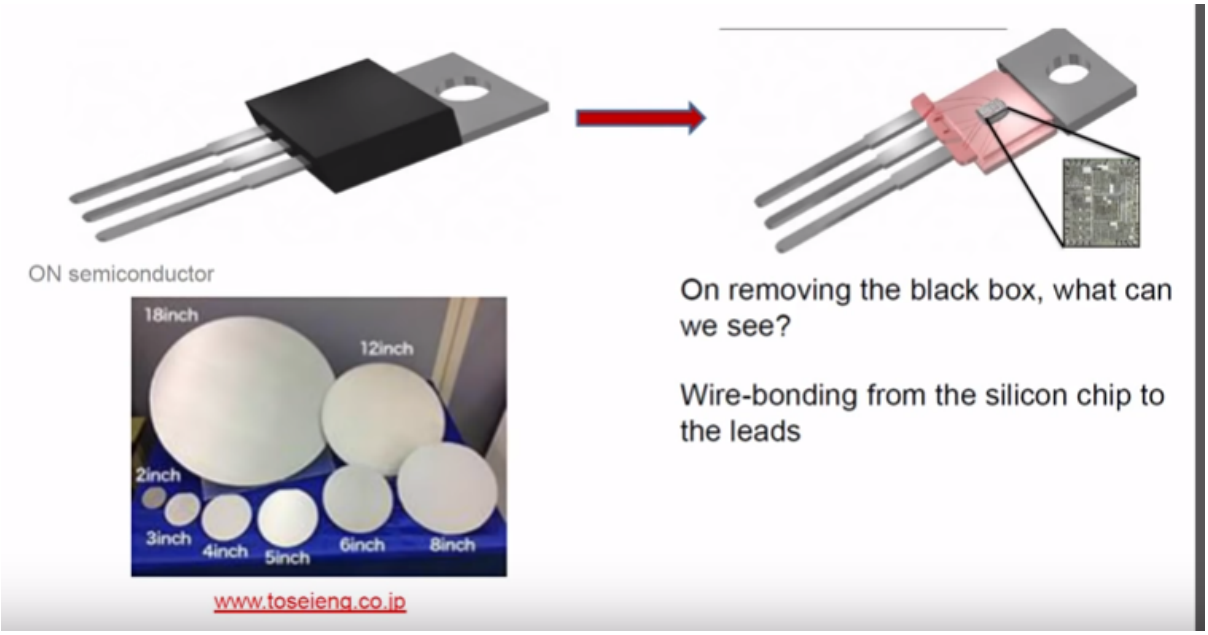

So if you see IC, from all semiconductor you will see when you remove it you will find a silicon chip, bonded with you have bonded with the external pins with the help of fire warning and when you talk about, a silicon wafer how this chip is fabricated? the strip is fabricated using silicon wafer silicon wafer can vary from 2 inch to 18 inch, also in industry now people are using silicon wafer with a higher larger diameter, so you can see there is a variation from 2, 3, 4, 5, 6, 8, 12, and 18.

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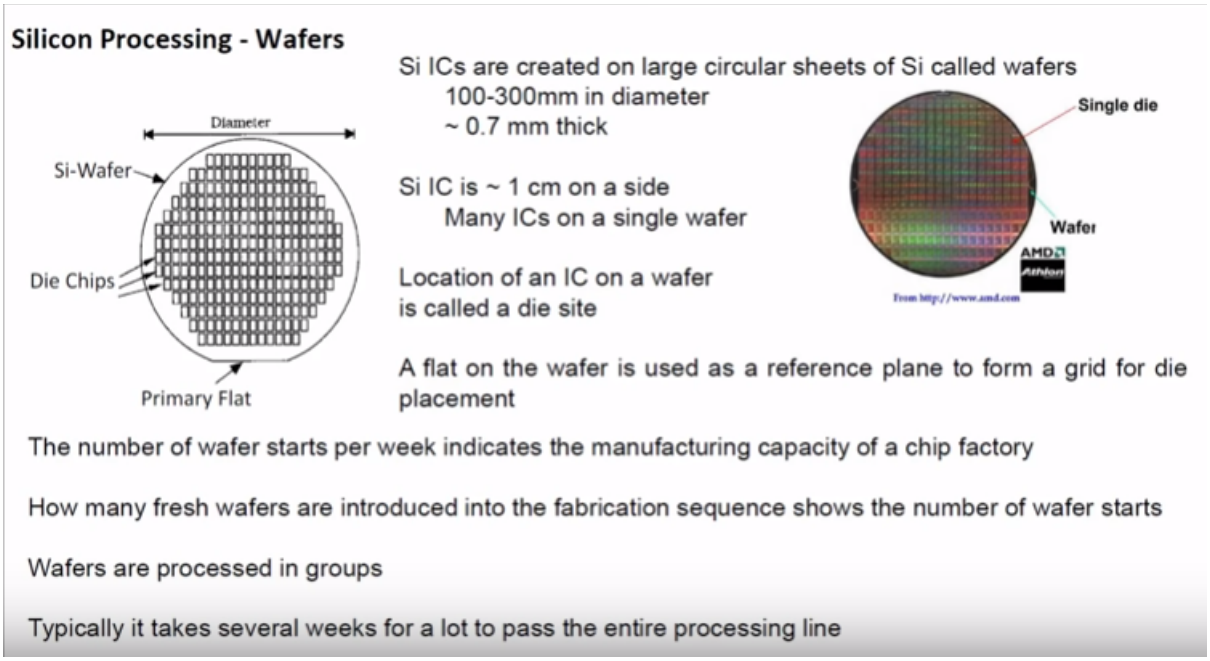

And then when we talk about silicon processing, then you can understand the silicon ICs are created a large circular sheets of silicon wafers, depending on the diameter of the wafer, the thickness would be different and then many ICS can be fabricated a single wafer, the location of an IC on a wafer is called a die site, so each single die you can see here has to be in a cut of or removed or diced from the silicon wafer and that is using the dicing saw that we have dicing saw equipment. We will quickly see in one of the class what are the facilities within a clean room to fabricate such a wafer and with lot of ICs and what are the equipment or what is the equipment used to remove or dice the single, single die from the rest of the wafer. Now we will also, I will show you in the next class, what are, how the silicon wafer will look like what are the flats in the silicon wafer and how the manufacturing capacity of a chips factory can be classified in the next class we will actually see the wafers and n-type and p-type wafer and a single flat versus a primary flat and secondary flat, how they are related? All right? Also typically it takes several weeks for a lot to entire process of to pass through and that processing line, all right? So if we talk about silicon, then let us see quickly how silicon is manufactured?

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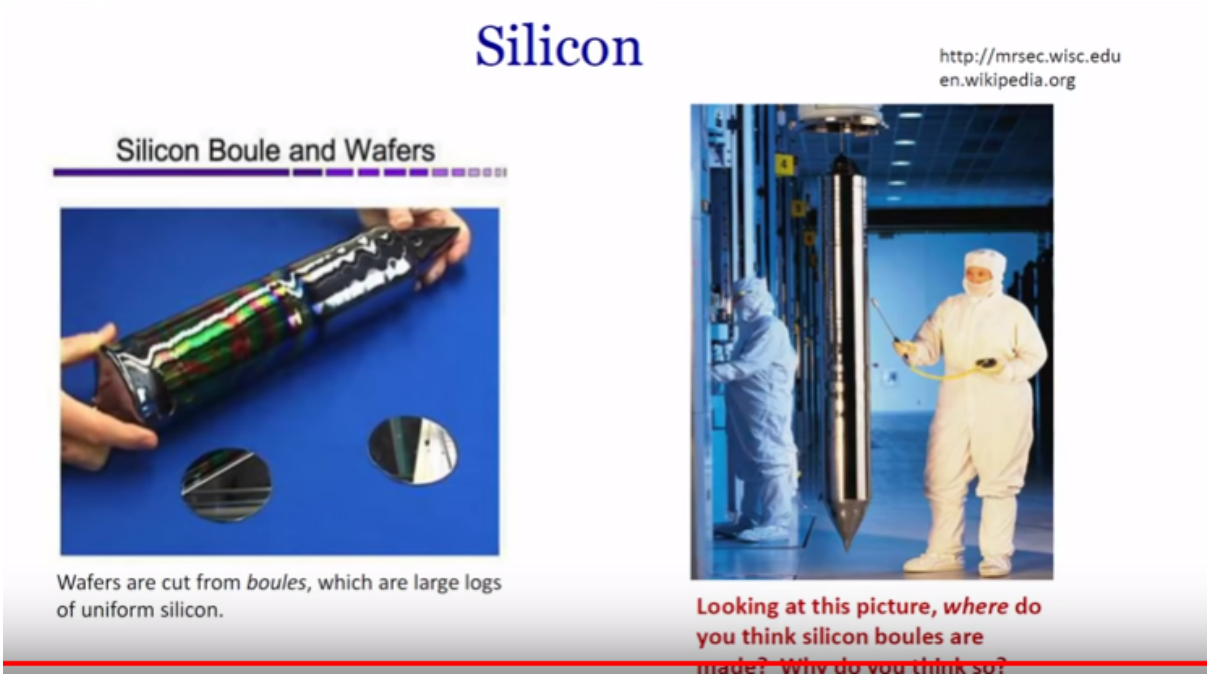

So if you see the slide, when you see a silicon, the silicon ball and wafers, wafers are cut from the balls, which are large logs of uniform silicon, you can see in the slide, while when you see the right side image, what do you see? Look that there is a, there is a engineer working on the silicon boules and what exactly you see? What kind of environment the person is working in? Then it's a clean room environment. Why we require clean room? Because we require clean room to avoid any contamination on to this silicon wafer, okay? So I'll show you the detail about silicon wafer how it looks like and then we'll continue in the next class what are the oxides or how can we grow different oxides, on silicon wafer, right? So just go through this quickly is more like an introduction in next class let us see

few more things and then we will jump on to the details of the operation amplifier, right? Till then you take care, I'll see you in the next class.