

EE6303 Linear Integrated Circuits and Applications
UNIT I : IC FABRICATION

1. What is an IC?

An integrated circuit is a miniature, low cost electronic circuit consisting of active and passive components that are irreparably joined together on a single crystal chip of silicon.

2. List the advantages of IC over discrete component circuit.

- ❖ Low cost (due to the large quantities processed)
- ❖ Small size.
- ❖ High reliability. (All components are fabricated simultaneously and there are no soldered joints)
- ❖ Improved performance. (Because of the low cost, more complex circuitry may be used to obtain better functional characteristics.)

3. Classify ICs on the basic of application, device used and chip complexity.

- ❖ Based on application, ICs can be classified as monolithic integrated circuits and hybrid circuits.
- ❖ Based on the active devices used, ICs can be classified as Bipolar (using BJT) and unipolar (using FET).
- ❖ Based on the chip complexity, ICs can be classified as SSI – Small Scale Integration, MSI – Medium Scale Integration, LSI – Large Scale Integration, VLSI – Very Large Scale Integration, ULSI – Ultra Scale Integration and GSI – Giant Scale Integration.

4. Name the technology used for the fabrication of transistors or ICs.

Monolithic Integrated Circuit Technology which means a circuit fabricated from a single stone or a single crystal.

5. List the basic processes used in the silicon planar technology.

Silicon wafer (substrate) preparation, Epitaxial growth, Oxidation, Photolithography, Diffusion, Ion implantation, Isolation Technique, Metallization, Assembly Processing and Packaging

6. Explain the word “Epitaxy”

The word epitaxy is derived from Greek word epi meaning ‘upon’ and taxy is the past tense of the word teinon meaning ‘arranged’. Therefore, epitaxy means arranging atoms in single crystal fashion upon a single crystal substrate, so that the resulting layer is an extension of the substrate crystal structure.

7. What is the function of silicon –di- oxide on an IC ?

Silicon dioxide has the property of preventing the diffusion of almost all impurities through it. It serves two very important purposes.

- ❖ SiO₂ is an extremely hard protective coating and is unaffected by almost all reagents except hydrofluoric acid. Thus it stands against any contamination.
- ❖ By selective etching of SiO₂, diffusion of impurities through carefully defined windows in the SiO₂ can be accomplished to fabricate various components.

8. Photolithography process is used for producing windows and the law that governs the diffusion process is the diffusion law .

9. Name the major crystal growth technique. What are ingots?

The major crystal growth technique is Czochralski crystal growth.

Ingots (1 to 2 inches in diameter and about 10 inches long) are grown from a silicon melt with a predetermined number of impurities.

10. What are positive photoresists?

Materials which are more soluble when subjected to light and therefore yield a positive image of the mask are known as positive photoresists.

11. What are negative photoresists?

Materials which are rendered less soluble in a developer solution by illumination yield a negative pattern of the mask and are called as negative photoresists.

12. What are the two types of capacitors that can be fabricated in IC?

Junction capacitor and Metal Oxide Semiconductor capacitor.

13. What is ion implantation?

Ion implantation is a technique used to introduce impurities into a silicon wafer.

14. List the advantages of ion implantation technique.

Ion implantation technique has two important advantages.

- ❖ It is performed at low temperatures, therefore, previously diffused regions have a lesser tendency for lateral spreading.
- ❖ In diffusion process, temperature has to be controlled over a large area inside the oven, whereas in ion implantation technique, accelerating potential and the beam current are electrically controlled from outside.

15. List the various isolation techniques used in ICs.

The various isolation techniques are PN junction isolation, Dielectric isolation.

16. Name the different types of IC packages.

TO – 5 glass metal package, Ceramic flat package, Dual – in- Line package (ceramic or plastic type)

17. What is meant by parasitic capacitance?

The isolation regions or junctions are connected by a significant barrier, or transition capacitance C_{TS} to the P type substrate, which capacitance can affect the operation of the circuit. Since C_{TS} is an undesirable by-product of the isolation process, it is called the parasitic capacitance.

18. Explain the need for making isolation islands.

Since a number of components are fabricated on the same IC chip, it is necessary to provide electrical isolation between different components and interconnections.

19. What is the undesirable by-product of PN diode isolation?

The undesirable by-product is the presence of transition capacitance at the isolating pn junctions, resulting in an inevitable capacitor coupling between the components & the substrate. This parasitic capacitance limits the performance of the circuit at high frequencies.

20. What is the advantage of using Aluminium in metallization?

- (i). It is relatively a good conductor.
- (ii) It is easy to deposit aluminium films using vacuum deposition
- (iii) Aluminium makes good mechanical bonds with silicon.
- (iv) Aluminium forms low resistance, non-rectifying (ohmic) contact with p-type silicon and the heavily doped n-type silicon.

21. List the types of monolithic capacitors.

- (i) Junction capacitor
- (ii) MOS or thin film capacitor

22. What are monolithic ICs?

Monolithic is Single stone. Monolithic ICs are made in a single piece of single crystal silicon

23. State the limitations of IC technology.

- (i) Can't be repaired
- (ii) Fabrication of Inductors with high values, transformers and chokes is difficult.

24. The semiconductor / substrate used for monolithic IC are single crystal silicon and that used for thin film are passive substrate such as glass or ceramic.

25. What are the advantages of pnp transistor over npn transistor in IC technology.

1. A vertical p-n-p transistor has the disadvantage that its collector has to be held at a fixed negative voltage.
2. Lateral p-n-p transistor has inferior characteristic as the base width is usually larger controlled by lateral diffusion on p-type impurities and photographic limitations during masking and alignment. Therefore p-n-p transistor normally gives current gain as low as 1.5 to 30 compared to 50 to 300 for the n-p-n transistor.
3. Collector region is heated during the base and emitter diffusions, so the diffusion coefficient of the collector impurities should be as small as possible to avoid the movement of the collector junction. Since n-type impurities have smaller diffusion constant than p-type impurities, the n-type collector moves very little while p-type moves appreciably. This makes the n-p-n transistor superior in performance with relatively easier process control.

26. What is meant by hybrid IC?

In hybrid circuits, separate component parts are attached to a ceramic substrate and interconnected by means of either metallization pattern or wire bonds.

27. Name some popular ICs.

National Semiconductor LM 741, Motorola MC1741, RCA-CA3741, Texas Instruments SN52741, Signetics N5741

28. Give the advantages of Schottky barrier diode over pn junction diode.

1. Less time delay from on to off.
2. Less forward voltage drop(0.3V) when compared to that of p-n diode(0.6V)

29. Define sheet resistance R_s .

$R_s = \rho/t$ (ohms per square), ρ – resistivity, t -material thickness

30. Explain why inductors are difficult to fabricate?

IC devices are essentially two dimensional as the depth dimension is usually very small compared to the lateral dimensions. IC inductors can be made in the form of a flat metallic thin film spirals by successive deposition of conduction patterns. Very small values of inductance of the order of nano-henry with low quality factor can be obtained.

31. What is the purpose of oxidation process in IC fabrication?

The two important purposes are:

- i) The SiO_2 layer acts as protective shield against contamination.
- ii) By selective etching of SiO_2 , the components can be easily fabricated.