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Epitaxy and Epitaxial Growth Methods

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Abstract – Epitaxy, widely used in bipolar ICs, is the arrangement of the atoms upon a crystalline substrate to form a continuous extension of the crystal structure. The resulting layer appears as an extension of the substrate. The atoms of the layer arrange themselves along the existing planes of the crystalline substrate and form bond with parent atoms.

In Epitaxy, a thin film of single crystal silicon is grown on the crystal of same material in vapour phase. It enhances the performance of bipolar transistors. The epitaxial layer is a high resistivity layer grown on low resistivity substrate in bipolar ICs. Epitaxy also improves the performance of Dynamic RAMs anf CMOS ICs. It allows control over the doping profile. Epitaxial layers are generally free from carbon and oxygen. The various types of epitaxy are.

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HOMOEPITAXY

In case of homo-epitaxy, the deposited layer and the substrate are of same material. Say Silicon epitaxial layer is deposited over single crystal silicon. Homo epitaxy is generally carried out in a quartz chamber. A susceptor is placed inside the reaction chamber. It performs two functions. It provides physical support to the Si wafers. Secondly it provides uniform thermal environment. The process of epitaxial growth is carried out at a very high temperature.

HETRO EPITAXY

In case of hetro epitaxy, the deposited layer and substrate are of different materials. An Example of hetro epitaxy is that of SOS (Silicon on Sapphire). In SOS , Si Layer is deposited on Sapphire substrate under controlled conditions. In hetro epitaxy an important aspect is that the crystal structure and atomic spacing of substrate must match with that of the layer to be deposited.

SELECTIVE EPITAXY

Selective epitaxy is the growth of single crystal Si on a substrate patterned with oxide or nitride. The nucleation of Silicon is suppressed by lowering the partial pressure. It allows lateral isolation with closer packing than standard isolation techniques.

EPITAXIAL GROWTH METHODS

Generally there are two methods of epitaxial growth.

- VPE (Vapour Phase Epitaxy)
- MBE(Molecular Beam Epitaxy)

VPE (VAPOUR PHASE EPITAXY)

VPE is a special case of Chemical Vapour Deposition. It includes the deposition of a solid material on the heated substrate by the chemical reaction of the compounds contained in the gas passing over the substrate. VPE is carried out in a quartz reaction chamber. In it, the material to be deposited is entered in this reaction chamber in vapour phase. The substrates/Silicon wafers are place on the susceptor in the chamber. The material in vapour form or gaseous form passes near the surface of substrates which are at high temperatures. So a chemical takes place and it produces the atoms or molecules which get deposited on the surface of the substrates. We have different types of reaction chambers.

Horizontal Reactors

Vertical Reactors

Cylindrical Reactors.

Generally radio frequency induction heating is used for heating the substrates. Radiant heating using halogen lamps may also be used.

The susceptor on which the wafers are placed is graphite coated. A copper induction coil serves a primary winding of the transformer. Susceptor serves as the secondary winding of the transformer. The eddy currents produced in the susceptor produce heat and raise the temperature

to the required value. The Epitaxial growth process consists of the following steps.

1. The hydrogen carrier gas is introduced into the reaction chamber.

2. The reactor is heated to the required temperature.

3. After the establishment of thermal equilibrium in the reactor, HCL gas is fed into it. The HCL gas reacts with Si at the surface of Si Wafers

$$Si + 4HCL \longrightarrow SiCl_4 + 2H_2$$

This results in vapour phase etching of the silicon surface at a temperature between 1150 ^{0}C and 1200^{0}C.

1. The temperature is the allowed to reduce and stabilize at growth temperature. HCL gas is flushed out. The vapour of $SiCl_4$ and hydrogen as a carrier gas are introduced in a tube for producing the epitaxial layer. The following reaction takes place.

$$SiCl_4(gas) + 2H_2(gas) \longrightarrow Si(Solid) + 4HCl(gas)$$

2. To produce doped epitaxial layers, Si and dopant(p or n type) are turned on and growth is allowed to take place.

3. After the completion of the growth dopant and Si flows are stopped and temperature is reduced.

4. The hydrogen flow is replaced by the nitrogen flow so as to open the reactor safely.

MOLECULAR BEAM EPITAXY

It is a non CVD technique of epitaxial growth. It includes evaporation instead of deposition. It is suitable for Silicon devices. In molecular beam epitaxy, the Silicon along with the dopants is evaporated and is transported at a very high velocity to the substrate. The process is carried out in ultra-high vacuum. The substrates are kept at a low temperature. As a result condensation takes place and the Si and dopants condense on substrates. MBE is generally carried out under a vacuum of 10^{-8} or 10^{-10} Torr. And in a temperature range of 500^{0}C to 900^{0}C.

Advantages of MBE

1. MBE involves only physical evaporation but no chemical reactions.

2. It is carried out at low temperature, so it does not suffer from out diffusion and auto doping.

3. Doping can be precisely controlled and different complicated doping profiles can be obtained.

4. The growth rate can be precisely controlled.

5. It is suitable for VLSI as thin epitaxial layers can be grown.

6. There are no boundary layer problems. Growth rate is equal at all the places in the chamber.

7. Linear doping profiles, as needed in varactor diodes, can be obtained.

Disadvantages of MBE

1. MBE has low throughput.

2. It is an expensive technique

REFERENCES

Fundamentals of semiconductor fabrication by S.M. Sze, G.S May, John Wiley and Sons.

Integrated circuits by K.R. Botkar

Micro ELectronics by Jacob Millman, Tata McGraw Hill

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