**The Cleanroom**

The fab is a giant cleanroom equipped with many types of air filters: to keep the manufacturing environment free from contamination, air from the outside must pass through many types of filters to eliminate all kinds of particles in order to maintain air quality of the cleanroom.

In addition the temperature, humidity, electrostatic discharge, pressure, magnetic fields and vibrations in the clean room must also be controlled.

Pure water as well as special liquids and gases required for the manufacturing of integrated circuits are supplied directly to manufacturing equipment through pipelines running throughout the clean room.

Before entering the cleanroom personnel must wear cleanroom garments, shoes, gloves and face masks to ensure cleanliness.

After changing clothes, personnel enter the air washroom to completely remove dust and particles from their bodies, preventing suspended particles from entering the fab.

An integrated circuit or IC is a system of electronic components and circuits miniaturized onto a silicon chip 1cm2 (centimeter square) or smaller.

An integrated circuit can process a large number of electronic signals and perform many complex functions.

If we look at that chip under a microscope, we can see that the apparently smooth surface is actually stacked with many components of different heights and shapes.

How are these components fabricated?

**The Silicon Wafer**

Let's start with the raw materials used to make the IC. Silicon wafers are a type of semiconductor material and the basic raw material used in the manufacturing of ICs.

By doping the wafer with elements, such as arsenic, phosphorus and boron, the conductivity and characteristics of the wafer are changed.

To make silicon wafers that meet the requirements for flatness and uniformity needed to make ICs, raw polycrystalline silicon material is first heated to a high temperature; by adjusting the speed and temperature a cylindrical ingot of crystalline silicon is pulled out.

The outer surface of the silicon ingot is then ground to a uniform diameter and sliced into thin silicon wafers. The edge and surface of the silicon wafers are ground and polished.

We can now use this silicon wafer to begin manufacturing integrated circuits

**The Design**

IC design engineers first use computer aided design systems to lay-out the patterns for each circuit of the IC.

By using electron beams or lasers, these patterns are then transferred to photomasks. The number of photomasks required for an integrated circuit product usually depends on the complexity of the design and the process technologies. Generally it requires at least 20 to 30 layers of photomasks, and the alignment between each layer must be very accurate.

**The Manufacturing**

The Fab for manufacturing ICs is divided into several major areas: each area has a unique function.

In the **Diffusion** area the silicon wafers are sent into an oven tube for thin-film growth at high temperatures. The silicon wafer stays in this environment where temperature and gas flow rate are accurately controlled for a period of time, and the surface reacts with the high temperatures and forms an insulating silicon compound film.

**Ion implantation** is a process used to implant charged ions into a specific region of the silicon wafer. Conductivity is changed by controlling the concentration and depth of the ions.

In the **Chemical Vapor Deposition** area, chemical reactions occur in the reaction chamber, and the reactive chemical vapors form a solid state reacted which is deposited on the chip surface as a thin film.

The wafer is now covered in a thin film and sent to the **Photolithography** area for transfer of circuit patterns. A thin layer of photoresist, a photosensitive liquid, is uniformly coated on the wafer surface. The photomask is then placed over the wafer. Light is exposed onto the wafer through the photomask, creating a pattern of exposed and unexposed areas, based on the pattern of the photomask. Unexposed areas remain covered with photoresist.

After photo lithography processing, the silicon wafer will be sent into the **Etching** area to etch out the exposed regions, that is the regions uncovered by the photoresist. The remaining pattern is the area needed for the circuits.

Once the wafer surface is covered with several thousand to several million electronic components, the components are connected with metal conducting wires so that they can perform their designated functions.

Here (**Physical Vapor Deposition** area) the surface etched wafer is sputter coated with a thin layer of metal film, processed with photo lithography, and etched to remove the unnecessary parts and leave the metal wires connecting each electronic element.

The **Chemical Mechanical Polishing** area uses mechanical principles and chemical reactions to effectively remove materials on the silicon wafer and make

it flat in preparation for later thin film deposition.

These complicated and precise processes are repeatedly performed in the fab to complete the manufacture of ICs.

Each silicon wafer is made up of hundreds, or even thousands, of chips.

Finally these chips must pass the **acceptance test (Electrical Wafer Sort)**.

After passing basic inspection, the chips are then diced, packaged and tested, according to the purpose of each integrated circuit.

**The Transport**

Throughout the entire manufacturing cycle the silicon wafers must be transported back and forth between the different manufacturing areas and manufacturing tools.

In a conventional 8-inch fab, the operator usually uses a cart to transport the silicon wafers manually. In recent years technological progress in the semiconductor industry has increased wafer size - 12 inches from 8 inches - this allows manufacturers to get more chips from a single silicon wafer and reduces the unit cost of IC manufacturing. The weight of a 12 inch wafer is twice that of an 8 silicon wafer, and the weight of 12 inch wafers together with the carrier tool are too heavy to transport manually. As a result, they are carried by automatic material handling systems.

TSMC leads the foundry segment in introducing automatic material transport systems and automatic real-time dispatch systems in its 12-inch fabs.