84.86 - Machines and apparatus of a kind used solely or principally for the manufacture of semiconductor boules or wafers, semiconductor devices, electronic integrated circuits or flat panel displays; machines and apparatus specified in note 9 (C) to this Chapter; parts and accessories.

8486.10 - Machines and apparatus for the manufacture of boules or wafers

8486.20 - Machines and apparatus for the manufacture of semiconductor devices or of electronic integrated circuits

8486.30 - Machines and apparatus for the manufacture of flat panel displays

8486.40 - Machines and apparatus specified in Note 9 (C) to this Chapter

8486.90 - Parts and accessories

This heading covers machines and apparatus of a kind used solely or principally for the manufacture of semiconductor boules or wafers, semiconductor devices, electronic integrated circuits or flat panel displays. However, this heading **excludes** machines and apparatus for measuring, checking, inspecting, chemical analysis, etc. (**Chapter 90**).

(A) MACHINES AND APPARATUS FOR THE MANUFACTURE OF BOULES OR WAFERS

This group covers machines and apparatus for the manufacture of boules or wafers such as :

(1) **One-melt furnaces** for zone melting and refining of silicon rods, oxidation furnaces for oxidizing the surface of wafers and diffusion furnaces for doping the wafers with impurities.

(2) **Crystal growers and pullers** for the production of extremely pure monocrystalline semiconductor boules from which wafers can be sliced.

(3) **Crystal grinders**, which grind the crystal boule to precise diameter required for wafers and to grind the flats on the boule to indicate the conductivity type and resistivity of the crystal.

(4) **Wafer slicing saws**, which slice wafers from a boule of monocrystalline semiconductor material.

(5) **Wafer grinders, lappers and polishers,** which prepare the semiconductor wafer for the fabrication process. This involves bringing the wafer within dimensional tolerances. Especially critical is the flatness of its surface.

(6) **Chemical mechanical polishers (CMP)**, which flatten and polish a wafer by combining chemical removal with mechanical buffing.

(B) MACHINES AND APPARATUS FOR THE MANUFACTURE OF SEMICONDUCTOR DEVICES OR OF ELECTRONIC INTEGRATED CIRCUITS

This group covers machines and apparatus for the manufacture of semiconductor devices or of electronic integrated circuits such as :

(1) **Film formation equipment**, which apply or produce various films on the surface of the wafer during the fabrication process. These films serve as conductors, insulators and semiconductors on the finished device. They may include oxides and nitrides of the substrate surface, metals, and epitaxial layers. The processes and equipments listed below are not necessarily limited to the generation of a particular type of film.

(a) **Oxidation furnaces**, which form a "film" of oxide on the wafer. The oxide is formed by the chemical reaction of the top molecular layers of the wafer with the applied oxygen or steam under heat.

(b) **Chemical Vapour Deposition (CVD) equipment**, which deposit various types of films which are obtained by combining the appropriate gases in a reactant chamber at elevated temperatures. This constitutes a thermochemical vapor-phase reaction. Operations may take place at atmospheric or low pressure (LPCVD) and may use plasma enhancement (PECVD).

(c) **Physical Vapour Deposition (PVD) equipment**, which deposit various types of films which are obtained by vaporizing a solid. For example :

(1) **Evaporation equipment**, in which the film is generated by heating the source material.

(2) **Sputtering equipment**, in which the film is generated by bombarding the source material (target) with ions.

(d) **Molecular Beam Epitaxy (MBE) equipment**, which grow epitaxial layers on a heated monocrystalline substrate in an ultrahigh vacuum using beams of molecules. The process is similar to PVD.

(2) **Doping equipmen**t, which introduce dopants into the wafer surface in order to modify the conductivity or other characteristics of a semiconductor layer such as :

(a) **Thermal diffusion equipment**, in which the dopants are introduced into the surface of the wafer by the application of gases under high temperatures.

(b) **Ion Implantation**, in which the dopants are "driven" into the crystal lattice structure of the surface of the wafer in the form of a beam of accelerated ions.

(c) **Annealing furnaces**, which repair the crystal lattice structures of the wafer damaged by ion implantation.

(3) **Etching and stripping equipment** for etching or cleaning surfaces of the wafers such as :

(a) **Wet etching equipment**, in which chemical etching materials are applied by spraying or immersion. Spray etchers provide more uniform results than bath etchers, since they perform the operation on one wafer at a time.

(b) **Dry plasma etching**, in which etching materials are presented as gases within a plasma energy field, providing an anisotropic etch profile. Dry-etchers use several different methods for creating gaseous plasma which removes thin film materials from semiconductor wafers.

(c) **Ion beam milling equipment**, in which ionized gas atoms are accelerated toward the wafer surface. The impact results in the top layer being physically removed from the surface.

(d) **Strippers or ashers**, using techniques similar to etching this apparatus removes the spent photoresist from the surface of the wafer after it has served its purpose as a " stencil ". This equipment may also remove nitrides, oxides, and polysilicon, with an isotropic etch profile.

(4) **Lithography equipment**, which transfer the circuit designs to the photoresist-coated surface of the semiconductor wafer such as :

(a) **Equipment for coating wafers with photoresist**. These include the photoresist spinners which apply liquid photoresist evenly over the surface of the wafer.

(b) **Equipment for exposing the photoresist coated wafer with the circuit design** (or a part thereof) :

(i) **Using a mask or reticle and exposing the photoresist to light** (generally ultraviolet) or, in some instances, X-rays :

(a) **Contact printers**, where the mask or reticle is in contact with the wafer during exposure.

(b) **Proximity aligners**, which are similar to contact aligners except actual contact does not take place between the mask or reticle and the wafer.

(c) **Scanning aligners**, which use projection techniques to expose a continuously moving slit across the mask and wafer.

(d) **Step and repeat aligners**, which use projection techniques to expose the wafer a portion at a time. Exposure can be by reduction from the mask to the wafer or 1:1. Enhancements include the use of an excimer laser.

(ii) **Direct write on wafer equipment**. These apparatus operate with no mask or reticle. They use an automatic data processing machine-controlled "writing beam" (such as an electron beam (E-beam), ion beam or laser) to "draw" the circuit design directly on the photoresist coated wafer.

(5) **Equipment for developing exposed wafers**. These include chemical baths similar to those used in photographic laboratory applications.

This heading also covers :

(i) **Centrifuges** for spin-coating insulating substrate or wafers with photoresist.

(ii) **Screen printers** for printing insulating substrate with etch-resisting ink.

(iii) **Laser scribing machines** for dividing wafers into chips (dicing).

(iv) **Wafer dicing saws**.

(C) MACHINES AND APPARATUS FOR THE MANUFACTURE OF FLAT PANEL DISPLAYS

This group covers the fabrication of substrates into a flat panel. However, it does not cover the manufacture of glass or the assembly of printed circuit boards or other electronic components onto the flat panel.

This heading covers machines and apparatus for the manufacture of flat panel displays such as :

(1) **Apparatus for etching, developing, stripping or cleaning**.

(2) **Apparatus for projection, drawing or plating circuit patterns**.

(3) **Centrifugal spin dryers and other drying appliances**.

(4) **Machines (spinners) designed to coat photographic emulsions**.

(5) **Ion implanters for doping**.

(6) **Furnaces, ovens and other equipment for diffusion, oxidation, annealing or rapid heating**.

(7) **Chemical Vapour Deposition and Physical Vapour Deposition apparatus**.

(8) **Machines for grinding and polishing**.

(9) **Machines for sawing, scribing or scoring**.

(D) MACHINES AND APPARATUS SPECIFIED IN NOTE 9 (C) TO THIS CHAPTER

This group covers machines and apparatus solely or principally of a kind used for :

(1) **the manufacture or repair of masks and reticles** (e.g., appliances (photoplotters) for the photographic production of photomasks and ion milling machines for the repair of masks and reticles);

(2) **assembling semiconductor devices or electronic integrated circuits**, e.g. :

(a) **Laser engraving machines** for engraving the plastic casing of completed monolithic integrated circuits or discrete semiconductor components.

(b) **Encapsulation equipment such as presses** for making the plastic casings for chips by pressing plastic material around the chips.

(c) **Wire bonders** for welding gold wires to the contact points of monolithic integrated circuits by ultrasonic or electrical compression welding.

(d) **Wafer bumping** which is a process where connections are formed on an entire wafer before dicing.

(3) **lifting, handling, loading or unloading of boules, wafers, semiconductor devices, electronic integrated circuits and flat panel displays** (e.g., automated material handling machines for transport, handling and storage of semiconductor wafers, wafer cassettes, wafer boxes and other material for semiconductor devices).

(E) PARTS AND ACCESSORIES

Subject to the general provisions regarding the classification of parts (see the General Explanatory Note to Section XVI), the heading includes parts and accessories for the machines and apparatus of this heading. Parts and accessories falling in this heading thus include, *inter alia*, work or tool holders and other special attachments which are solely or principally used for the machines and apparatus of this heading.