Additional U.S. Note

1. For the purposes of this section, the term "printed circuit assembly" means goods consisting of one or more printed circuits of heading 8534 with one or more active elements assembled thereon, with or without passive elements. For the purposes of this note, "active elements" means diodes, transistors and similar semiconductor devices, whether or not photosensitive, of heading 8541, and integrated circuits and microassemblies of heading 8542.

Statistical Note

1. Provisions for semiconductor manufacturing and testing machines and apparatus cover products for the growth and processing of semiconductor materials, such as silicon and gallium arsenide, the processing of such materials into semiconductor devices and the testing of such devices (in general the testing equipment, as well as some of the processing equipment, is classified in chapter 90). More specifically the goods include the following:

    (a) Wafer manufacturing equipment:

    (i) Crystal growers & pullers. - used to produce extremely pure monocrystalline semiconductor boules from which wafers can be sliced. Most common methods employed in these crystal growers and pullers are the Czochralski and float zone methods.

    (ii) Wafer preparation equipment:

    (A) Crystal grinders - used to 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.

    (B) Wafer slicing saws - used to slice wafers from a boule of monocrystalline semiconductor material.

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

    (b) Mask fabrication and repair equipment -

    (i) Fabrication equipment - used to transfer design patterns to a mask or reticle, this equipment generally utilizes optical, electron beam or X-rays to write circuit patterns on photoresist coated substrates. After development, these substrates become the mask or reticle for wafer fabrication.

    (ii) Repair equipment - this equipment generally utilizes focused ion beams or laser beams. They are used directly on the mask or reticle to remove chrome.

    (c) Wafer fabrication equipment:

    (i) Film formation equipment - used to 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 - used to 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 Vapor Deposition (CVD) equipment - used to 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 Vapor Deposition (PVD) equipment - used to deposit various types of films which are obtained by vaporizing a solid.

    (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 - used to grow epitaxial layers on a heated monocrystalline substrate in an ultrahigh vacuum using beams of molecules. The process is similar to PVD.

    (ii) Doping equipment - which is used to introduce dopants into the wafer surface in order to modify the conductivity or other characteristics of a semiconductor layer:

    (A) Thermal diffusion equipment - in which the dopants 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 a beam of accelerated ions.

    (C) Annealing furnaces - which are used to repair the crystal lattice structures of the wafer damaged by ion implantation.