85.41 - Diodes, transistors and similar semiconductor devices; photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes; mounted piezo-electric crystals (+).

8541.10 - Diodes, other than photosensitive or light emitting diodes

- Transistors, other than photosensitive transistors :

8541.21 - - With a dissipation rate of less than 1 W

8541.29 - - Other

8541.30 - Thyristors, diacs and triacs, other than photosensitive devices

8541.40 - Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes

8541.50 - Other semiconductor devices

8541.60 - Mounted piezo-electric crystals

8541.90 - Parts

(A) DIODES, TRANSISTORS AND SIMILAR SEMICONDUCTOR DEVICES

These are defined in Note 8 (a) to this Chapter.

The operation of the devices of this group is based on the electronic properties of certain " semiconductor " materials.

The main characteristics of these materials is that at room temperature their resistivity lies in the range between that of conductors (metals) and that of insulators. They consist, for instance, of certain ores (e.g., crystal galena), tetravalent chemical elements (germanium, silicon, etc.) or combinations of chemical elements (e.g., trivalent and pentavalent elements, such as gallium arsenide, indium antimonide).

Semiconductor materials consisting of a tetravalent chemical element are generally monocrystalline. They are not used in their pure state but after very light doping (in a proportion expressed in parts per million) with a specific " impurity " (dopant).

For a tetravalent element, the " impurity " may be a pentavalent chemical element (phosphorus, arsenic, antimony, etc.) or a trivalent element (boron, aluminium, gallium, indium, etc.). The former produce n-type semiconductors with excess electrons (negatively charged); the latter produce p-type semiconductors with electron deficiency, that is to say that holes (positively charged) predominate.

Semiconductor materials combining tri- and pentavalent chemical elements are also doped.

In the semiconductor materials consisting of ores, the impurities contained naturally in the ore act as dopants.

The semiconductor devices of this group generally comprise one or more " **junctions** ", between p-type and n-type semiconductor materials.

They include :

(I) **Diodes** which are two-terminal devices with a single p n junction; they allow current to pass in one direction (forward) but offer a very high resistance in the other (reverse). They are used for detection, rectification, switching, etc.

The main types of diodes are signal diodes, power rectifier diodes, voltage regulator diodes, voltage reference diodes.

(II) **Transistors** are three- or four-terminal devices capable of amplification, oscillation, frequency conversion, or switching of electrical currents. The operation of a transistor depends on the variation in resistivity between two of the terminals upon the application of an electric field to the third terminal. The applied control signal or field is weaker than the resulting action brought about by the change in resistance and thus amplification results.

Transistors include :

(1) Bipolar transistors, which are three-terminal devices consisting of two diode type junctions, and whose transistor action depends on both positive and negative charge carriers (hence, bipolar).

(2) Field effect transistors (also known as metal oxide semiconductors (MOS)), which may or may not have a junction, but which depend on the induced depletion (or enhancement) of available charge carriers between two of the terminals. The transistor action in a field effect transistor employs only one type of charge carrier (hence, unipolar). A parasitic body diode, which is produced in a MOS type transistor (also known as MOSFET), may operate as a freewheeling diode during inductive load switching. MOSFET which have four terminals are known as tetrodes.

(3) Insulated Gate Bipolar Transistors (IGBT), which are three-terminal devices consisting of a gate terminal and two load terminals (emitter and collector). By applying appropriate voltages across the gate and emitter terminals, current in one direction can be controlled, i.e. turned on and turned off. IGBT chips may be incorporated with diodes in a single package (packaged IGBT devices), which protect the IGBT device and allow it to continue to function as a transistor.

(III) **Similar semiconductor devices**. The “ similar ” devices referred to here are semiconductor devices whose operation depends on variations in resistivity on the application of an electric field.

They include :

(1) **Thyristors**, consisting of four conductivity regions in semiconducting materials (three or more p n junctions) through which a direct current passes in a predetermined direction when a control pulse initiates conductivity. They are used as controlled rectifiers, as switches or as amplifiers and function as two interlocking, complementary transistors with a common collector/base junction.

(2) **Triacs** (bi-directional triode thyristors), consisting of five conductivity regions in semiconducting materials (four p n junctions) through which an alternating current passes when a control pulse initiates conductivity.

(3) **Diacs**, consisting of three conductivity regions in semiconducting materials (two p n junctions) and used to provide the pulses required to operate a triac.

(4) **Varactors** (or variable capacitance diodes).

(5) **Field effect devices**, such as gridistors.

(6) **Gunn effect devices**.

However, this group **does not include** semiconductor devices which differ from those described above in that their operation depends primarily on temperature, pressure, etc., such as non-linear semiconductor resistors (thermistors, varistors, magneto-resistors, etc.) (**heading 85.33**).

For photosensitive devices the operation of which depends on light rays (photodiodes, etc.), see group (B).

The devices described above fall in this heading whether presented mounted, that is to say with their terminals or leads or packaged (components), unmounted (elements) or even in the form of undiced discs (wafers). However, natural semiconductor materials (e.g., galena) are classified in this heading only when mounted.

The heading also **excludes** chemical elements of **Chapter 28** (for example, silicon and selenium) doped for use in electronics, in the form of discs, wafers, or similar forms, polished or not, whether or not coated with a uniform epitaxial layer, **provided** they have not been selectively doped or diffused to create discrete regions.

(B) PHOTOSENSITIVE SEMICONDUCTOR DEVICES

This group comprises photosensitive semiconductor devices in which the action of visible rays, infra-red rays or ultra-violet rays causes variations in resistivity or generates an electromotive force, by the internal photoelectric effect.

Photoemissive tubes (photoemissive cells) the operation of which is based on the external photoelectric effect (photoemission), belong to **heading 85.40**.

The main types of photosensitive semiconductor devices are :

(1) **Photoconductive cells (light dependent resistors)**, usually consisting of two electrodes between which is a semiconductor substance (cadmium sulphide, lead sulphide, etc.) whose electrical resistance varies with the intensity of illumination falling on the cell.

These cells are used in flame detectors, in exposure meters for automatic cameras, for counting moving objects, for automatic precision measuring devices, in automatic door opening systems, etc.

(2) **Photovoltaic cells**, which convert light directly into electrical energy without the need for an external source of current. Photovoltaic cells based on selenium are used mainly in luxmeters and exposure meters. Those based on silicon have a higher output and are used, in particular, in control and regulating equipment, for detecting light impulses, in communication systems using fibre optics, etc.

Special categories of photovoltaic cells are :

(i) **Solar cells**, silicon photovoltaic cells which convert sunlight directly into electric energy. They are usually used in groups as sources of electric power, e.g., in rockets or satellites employed in space research, for mountain rescue transmitters.

The heading also covers solar cells, whether or not assembled in modules or made up into panels. However the heading **does not cover** panels or modules equipped with elements, however simple, (for example, diodes to control the direction of the current), which supply the power directly to, for example, a motor, an electrolyser (**heading 85.01**).

(ii) **Photodiodes** (germanium, silicon, etc.), characterised by a variation in resistivity when light rays strike their p n junction. They are used in automatic data processing (reading of data storage), as photocathodes in certain electronic tubes, in radiation pyrometers, etc. **Phototransistors** and **photothyristors** belong to this category of photoelectric receivers.

The devices of this category differ, when packaged, from the diodes, transistors and thyristors of Part (A) above by their housing, which is partly transparent to permit the passage of light.

(iii) **Photocouples** and **photorelays** consisting of electroluminescent diodes combined with photodiodes, phototransistors or photothyristors.

Photosensitive semiconductor devices fall in this heading whether presented mounted (i.e., with their terminals or leads), packaged or unmounted.

(C) LIGHT EMITTING DIODES

Light emitting diodes, or **electroluminescent diodes**, (based, *inter alia*, on gallium arsenide or gallium phosphide) are devices which convert electric energy into visible, infra-red or ultra-violet rays. They are used, e.g., for displaying or transmitting data in control systems.

Laser diodes emit a coherent light beam and are used, e.g., in detecting nuclear particles, in altimetering or in telemetering equipment, in communication systems using fibre optics.

(D) MOUNTED PIEZO-ELECTRIC CRYSTALS

These are mainly barium titanate (including polycrystalline polarised elements of barium titanate), lead titanate zirconate or other crystals of **heading 38.24** (see the corresponding Explanatory Note), or quartz or tourmaline crystals. They are used in microphones, loudspeakers, ultrasonic apparatus, stabilised frequency oscillating circuits, etc. They are classified here **only** if mounted. They are generally in the form of plates, bars, discs, rings, etc., and must, at least, be equipped with electrodes or electric connections. They may be coated with graphite, varnish, etc., or arranged on supports and they are often inside an envelope (e.g., metal box, glass bulb). If, however, because of the addition of other components, the complete article (mounting plus crystal) can no longer be regarded as merely a mounted crystal but has become identifiable as a specific part of a machine or appliance, the assembly is classified as a part of the machine or appliance in question : e.g., piezo-electric cells for microphones or loudspeakers (**heading 85.18**), sound-heads (**heading 85.22**), pick-up elements (feelers) for ultrasonic thickness measuring or detecting instruments (generally classified in accordance with Note 2 (b) to Chapter 90 or in **heading 90.33**, as the case may be), quartz oscillators for electronic watches (**heading 91.14**).

This heading also **excludes** unmounted piezo-electric crystals (generally **heading 38.24**, **71.03** or **71.04**).

85.41

PARTS

Subject to the general provisions regarding the classification of parts (see the General Explanatory Note to Section XVI), parts of the goods of this heading are classified here.

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Subheading Explanatory Note.

Subheading 8541.21

The dissipation rate of a transistor is measured by applying the specified operating voltage to the device and measuring the continuous power handling capability using a case temperature limit of 25º C. For example, if a transistor is capable of handling a 0.2 ampere load continuously at a specified operating voltage of five volts while maintaining a case temperature of 25º C, its dissipation rate is 1 watt (Amperage x Voltage = Wattage).

For transistors with a means of heat dissipation (for example, a tab, a metal case), the reference temperature of 25º C is that of the bottom or of the case, whereas for other transistors (for example, with simple casing of plastics), the room temperature applies.