Chapter 1 Product Overview of Fuji Discrete IGBT

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This chapter describes the product overview of Fuji discrete IGBT.

1. Transformation and Features of Fuji Discrete IGBT

The IGBT has a structure in which p+ layer is added to the drain side of the MOSFET, and is a device that realizes low resistance at high current by using conductivity modulation of the base layer. In particular, IGBT in which n-type channel is formed when positive voltage is applied to the gate is called n-channel type.

The IGBT structure can be divided roughly into the surface gate structure and the bulk structure that constitutes the base layer. There are two types of surface gate structures. One is the planar gate structure, in which the gates are formed on the wafer surface, namely the chip surface. The other is the trench gate structure, in which the trenches are made to form the gates in the wafer. On the other hand, the bulk structure can be divided roughly into the punch-through type, in which the depletion layer contacts the collector side at turn-off, and the non-punch-through type, in which it does not contact the collector side. Fig.1-1 shows the structural comparison of IGBT.

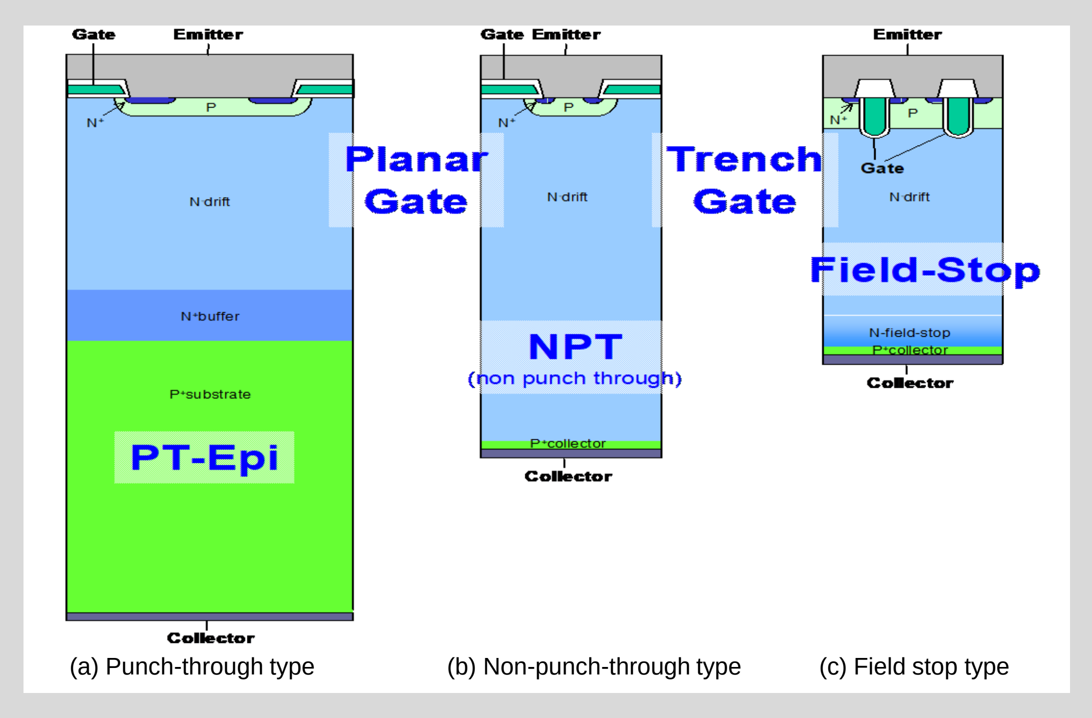

Fig.1-1 Structure comparison of IGBT

Fuji Electric has supplied IGBT to the market since it commercialized them in 1988. The planar-gate punch-through IGBT was the mainstream IGBT at that time. Punch-through type IGBTs at that time used epitaxial wafers, and achieved low on-voltage by injecting carriers from the collector side. At the same time, the lifetime control technology was used because the carriers, which were high-injected into the n-base layer, had to be removed quickly at turn-off. The low on-state voltage and the low turn-off switching loss (E_{off}) were materialized in this way. However, when the lifetime control technology was used, the improvement of characteristics was limited because the high-injected carriers were suppressed by this technology. In addition, the on-state voltage characteristics varied and so the IGBT at that time could not meet the increasing demand for large capacity by using them in parallel.

The non-punch-through IGBT was developed to solve these problems. In this IGBT, the injection efficiency of carriers was suppressed by controlling the impurity concentration in the collector (p+ layer) and the transport efficiency was increased by making the n-base layer thinner. The non-punch-through IGBT used the floating zone (FZ) wafer instead of the epitaxial wafer and so had the advantage that it was less affected by crystal defect. On the other hand, in order to achieve low on-state voltage, it was necessary to improve the transport efficiency and reduce the thickness of the n-base layer. Fuji Electric has developed new technologies for production of thinner wafers and improved the characteristics. In order to further improve the characteristics, IGBT with a thinner chip thickness is required. However, the thickness of the n-base layer constitutes most of the chip thickness. Reducing the thickness will make it impossible to maintain the breakdown voltage. The field stop (FS) structure solved this problem that prevented the improvement of the characteristics. In the FS structure, the high concentration FS layer is provided in the n-base layer, enabling improvement of the characteristics. Fuji Electric has also advanced the miniaturization of surface structure that is imperative to improve the characteristics of IGBT. The IGBT device consists of many arranged structures called cells. The more the IGBT cells are provided, the lower the on-state voltage will be. Therefore, the surface structure has changed from the planar structure, in which the IGBT cells are made planarly on the wafer surface, to the trench structure, in which the trenches are formed on the silicon surface and the gate structure is formed three-dimensionally.

2. Structure of Discrete IGBT

Fig.1-2 shows the discrete product structure of the TO-247-P with built-in IGBT and FWD. Fig.1-2 (a) shows the external structure, and Fig.1-2 (b) shows the internal structure. Terminal ①, ②, and ③ indicates the gate, collector, and emitter terminal, respectively. Unlike IGBT modules, discrete IGBT do not use insulating substrate.

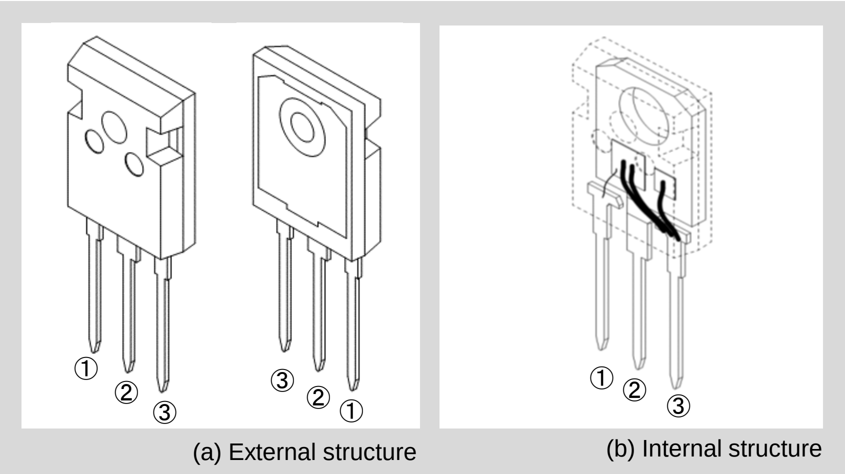

Fig.1-2 Structural diagram of discrete IGBT

3. Code Symbols

FGW40XS120C(example) : XS series

FG W 40 XS 120 C

- **C** – Diode type
  - C, E : w/ Diode (full rated)
  - D : w/ Diode
  - blank : w/o Diode
- **120** – V_{CE} : V_{CE} × 0.1
- **XS** – XS series
- **40** – I_C [A] @ 100 ℃
- **W** – PKG code W : TO-247-P, TO-247-P2
  Z : TO-247-4-P2
- **FG** – Fuji discrete IGBT

FGW40N120WD (example) : except XS series

FG W 40 N 120 W D

- **D** – Diode type
  - C, E : w/ Diode (full rated)
  - D : w/ Diode
  - Blank : w/o Diode
- **W** – Series W : High-Speed W series
  - H : High-Speed V series
  - V : V series
  - RB : RB-IGBT
- **120** – V_{CE} : V_{CE} × 0.1
- **N** – Polarity N : n - channel
- **40** – I_C [A] @ 100 ℃
- **W** – PKG code W : TO-247-P, TO-247-P2
  Z : TO-247-4-P2
- **FG** – Fuji discrete IGBT

4. RoHS Compliance

The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) was enacted by the EU on July 1, 2006 to restrict the use of certain hazardous substances in electrical and electronic equipment.

The use of the following ten substances are restricted: Pb(lead), Cd(cadmium), Cr6+(hexavalent chromium), Hg(mercury), PBB(polybrominated biphenyl), PBDE(polybrominated diphenyl ether), DEHP(bis(2-ethylhexyl)phthalate), BBP(benzyl butyl phthalate), DBP(dibutyl phthalate) and DIBP(diisobutyl phthalate).

Products containing these 10 substances above the threshold (0.01% for Cd, 0.1% for others) cannot be sold in the EU, but exemptions are granted for applications that are technically difficult to replace.

Our discrete IGBT products are RoHS compliant. Lead-free solder (Pb less than 0.1%) is used for the dip solder of the terminal part.