

2000
Development of a 4.5-kV 1.5-kA
injection-enhanced gate transistor (IEGT)
(Toshiba)
~ Discrete Semiconductor/Others ~

In 1992, Mitsuhiro Kitagawa and Akio Nakagawa of Toshiba developed and announced IEGT (Injection Enhanced Gate Transistor). In 2000, IEGT chips were mounted on a 125 φ multichip pressure contact package (Press Pack), and 4.5kV, 1.5kA IEGT devices were developed.

The IEGT is a device with increased excess carrier density in the entire n layer like thyristor and GTO, etc. in order to further increase the withstand voltage and power of the IGBT.

As shown in Fig.1, the density of holes injected from the collector decreases as they get closer to the emitter in ordinary IGBT. As a result, the excess carrier density of the n-layer is not uniform and the conductivity modulation effect is not sufficiently realized. On the other hand, in the IEGT shown in Fig. 2, the gate structure has a trench structure and by combing out the emitter n+ region, excess carriers are retained in the n- layer near the emitter. With this structure, a strong conductivity modulation effect can be obtained over the entire n- layer, and further reduction of the ON-resistance value is realized.

In 1996, Mitsubishi Electric realized the same principle by inserting the n-layer between the emitter p-layer and the n- layer, and announced it as CSTBT (Carrier Stored Trench Bipolar Transistor). Fig. 3 shows the CSTBT structure.

IEGT, as with the normal IGBT, is easy to do a gate drive, and unlike thyristors and GTOs, it has a self-sustaining function, so the protection circuit at load short-circuit accident becomes simpler. Furthermore, it is possible to increase the switching frequency, thereby achieving a compact system. Furthermore, since parallel connection is possible, many chips can be connected in parallel. By adopting a Press Pack or a power module (PM), controlling high power equivalent to thyristor and GTO becomes possible. Toshiba developed a multichip pressure-contact type package (Press Pack) that could provide high reliability, and it completed an IEGT of 4.5kV/4kA assembled in a 125φ multichip pressure-contact type package in 2000.

As a result, it came to be adopted in electric power conversion system such as generation and transmission of electric power which required high reliability, also in the inverters replacing conventional thyristors and GTO for locomotives, high-speed rail cars, large industrial motors, and so on.

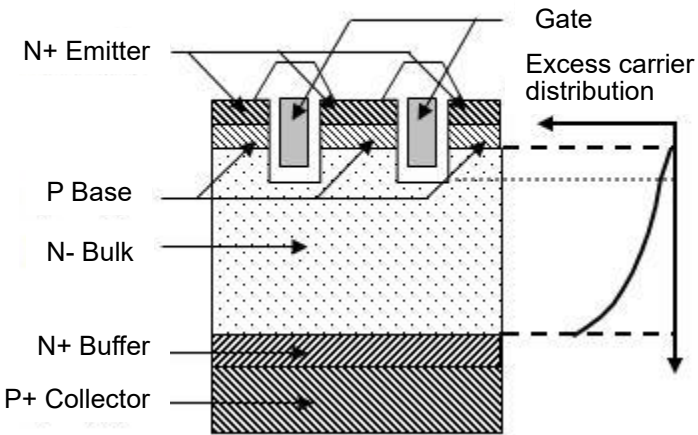


Fig. 1: Trench type IGBT structure

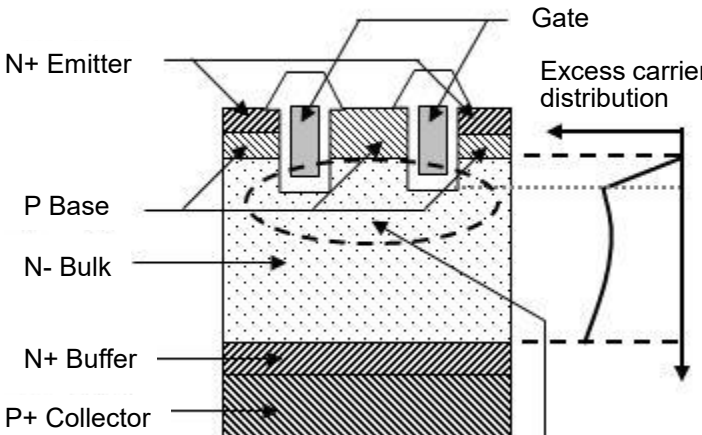


Fig.2: IEGT structure

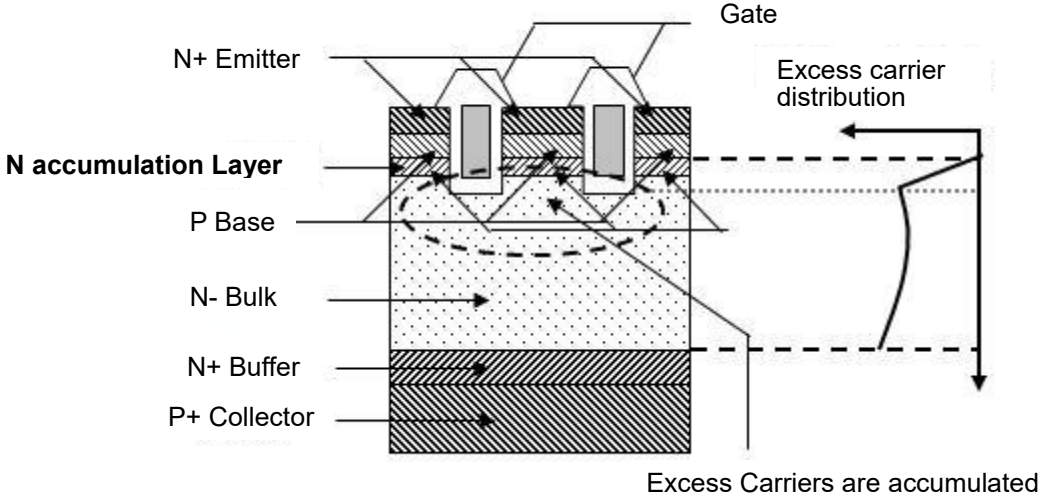


Fig.3: CSTBT structure by Mitsubishi Electric

References:

- (1) M. Kitagawa et al. "A 4500V Injection Enhanced Insulated Gate Bipolar Transistor (IEGT) Operating in a Mode Similar to a Thyristor", IEEE IEDM Digest of Technical Papers, pp. 679-682 (1993)
- (2) H. Matsuda, "High Power (4.5kV/4kA turn-off) IEGT" EPE'99-Lausanne, No.812, pp.1-4, (1999)
- (3) T. Takahashi, et al. "Carrier Stored Trench-Gate Bipolar Transistor (CSTBT) Novel Power Device for High Voltage Application" ISPSD p.75, (1996)