InP/InGaAs Tunneling-Emitter Bipolar Transistor (TEBT) with a Step-Graded Collector Structure Prepared by MOCVD

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An interesting InP/InGaAs tunneling-emitter bipolar transistor (TEBT) with a step-graded collector structure, grown by MOCVD, is fabricated and studied. Due to the mass filtering for electrons and holes, a thin barrier can be used to replace the wide-gap emitter. And a better DC characteristics is found. Due to the use of thin emitter layer, we expect the RF characteristic will be improved. Experimentally, due to the use of step-graded junction, a very small offset voltage of 80mV and a common-emitter current gain of 75 are obtained. In addition, the InP/InGaAsP/InGaAs step-graded collector structure achieves the high breakdown voltage of 14.6V and the knee-shaped effect is not observed in the transistor performances.

The studied TEBT structure was grown on Fe-doped InP semi-insulating substrates by a low-pressure metal organic chemical vapor deposition (LP-MOCVD) system. Silicon and zinc were used as the n-type and p-type dopants, respectively. Figure 1 shows the epitaxial layer structures of the studied DHBT's. The current as a function of base-emitter (B-E) and base-collector (B-C) bias voltage are shown in figure 2. Due to the use of large energy-gap material, a high breakdown voltage larger than 10V is found. In addition, the step-graded junction can also improve the asymmetrical junction by changing energy gap little by little to reduce the offset voltage. Figure 3 shows the common-emitter output characteristics for the studied TEBT's with the emitter size of $50x50\mu m^2$. The common-emitter I-V characteristics near the origin are enlarged and shown in the insertion of Fig.3.The offset voltage of the studeid TEBT's is 80mV.

The fabrication and characterization of an InP/InGaAs TEBT with an InP tunneling barrier and composite collector structure have been presented. The adoption of undoped InP tunneling barrier and InP collector achieve a very low offset voltage of 80mV and high breakdown voltage of 14.6V for the studied step-graded junction TEBT. The step-graded B-C heterojunction is designed to minimize the current blocking effect. The introduction of InGaAsP step-graded layers reduces the carrier multiplication, but it enhances the occurrence of self-heating effect. The studied step-graded TEBT has the current gain as high as 150 at I_C=30mA without the current gain fall-off phenomenon.

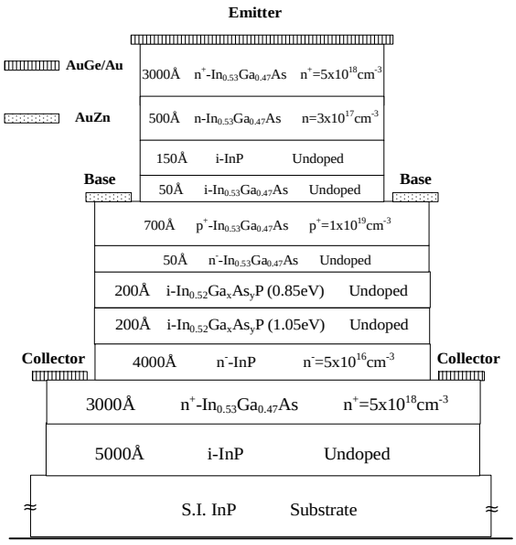

Fig. 1 The epitaxial layer structures of the studied TEBT.

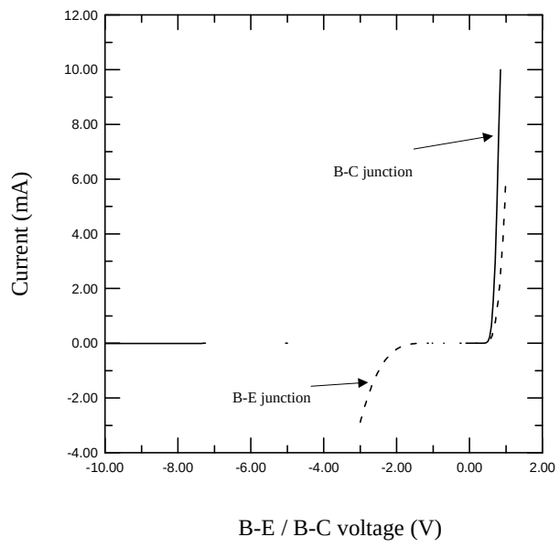

Fig. 2 The diode characteristic for studied TEBT device.

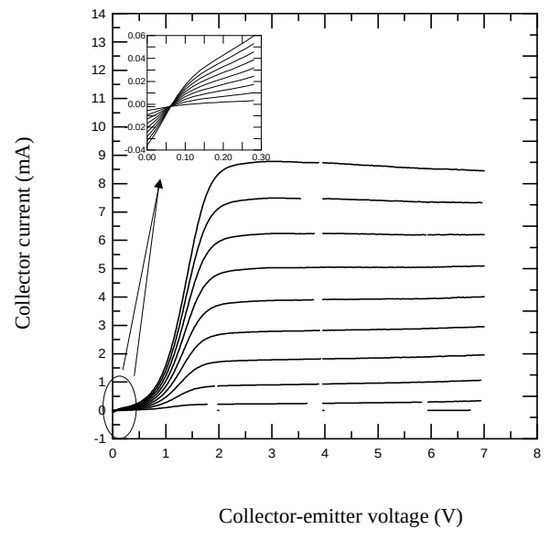

Fig. 3 Common-emitter current-voltage characteristics of the step-graded junction TEBT.