Low Voltage Operation Phototransistor with InGaP/AlGaAs/GaAs Composite Emitter

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The heterojunction phototransistor (HPT) is a very attractive alternative to such photoreceiver OEIC since it has a good compatibility with HBT's and provides a high optical gain without a high bias or the additional avalanche noise [1]. Both AlGaAs/GaAs and InGaP/GaAs based HBT's/HPT's have been reported as preamplifiers of the photoreceiver OEIC. Recently, the trend in portable electronics is to achieve greater efficiency at lower bias conditions for longer battery life. The key requirement for such devices operated at low biased condition is to reduce the emitter-base turn-on voltage and hence collector-emitter saturation voltage.

The authors have previously reported a new composite-emitter HBT with a AlGaAs/GaAs digital graded superlattice emitter to smooth out potential spike. Thus we obtained a emitter-base turn on voltage as low as 0.87 V [2]. In this paper, we will report a new HPT having a the same device structure as in [2]. As shown in Fig.1 the fabricated HPT has a emitter area of 150×150 μm^2 and a base-collector junction area of 250×250 μm^2, respectively. The laser diode of 670 nm wavelength with optical power of 0.5 μW was used for the optical illumination and photo-measurements were performed on wafer by the front side illumination.

Figure 2 shows the common-emitter characteristics for the fabricated HPT's under dark and illumination Both show very small offset voltage and a low saturation voltage indicating the DGSE together with InGaP layer really functions as a graded layer as described in [2]. Figure 3 shows the Gummel plots for HPT's measured under dark and optical illumination. Note that the input parameter is the base-emitter voltage instead of the base current in Fig.2. Thus we find an abruptly reduced base current within turn-on voltage regime in Fig.3. This is because photo-generated holes in the base-collector are transported into the base, resulting a reverse current. Figure 4 shows the dc current gains as a function of base-emitter bias. We find that the current gains at the large base-emitter voltage are nearly the same. Whereas the current gains at base-emitter voltage smaller than 1.0 V are significantly enhanced.

In conclusion, we have fabricated a new HPT by employing a InGaP/DGSE composite emitter and discussed its possible applications to low voltage operation photoreceivers. In addition, a modified Ebers-Moll model was used to analyze what differences between common-emitter characteristics with input base current and Gummel plots with input base-emitter voltage. Detailed experimental results and analysis will be also reported in this presentation.

REFERENCES

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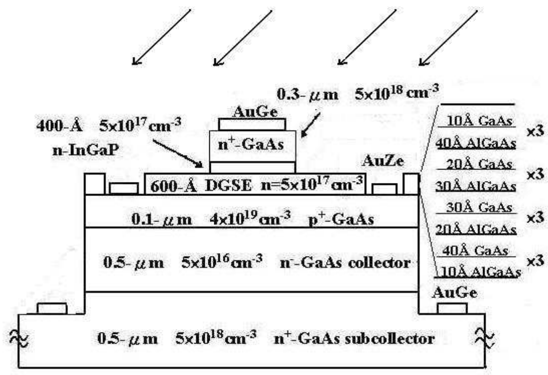

Fig. 1: The schematic cross section for the studied HBT/HBT structure.

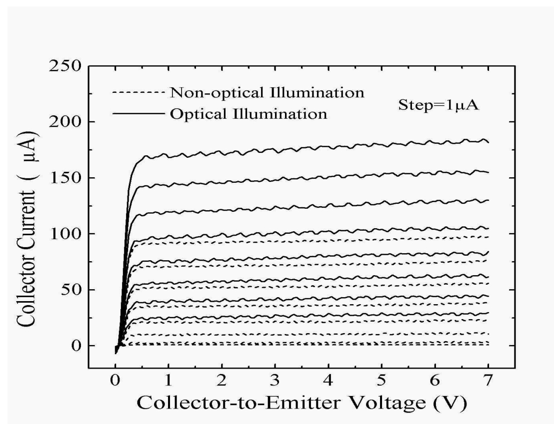

Fig. 2: The measured common-emitter characteristics for HBT/HPT under dark and optical illumination.

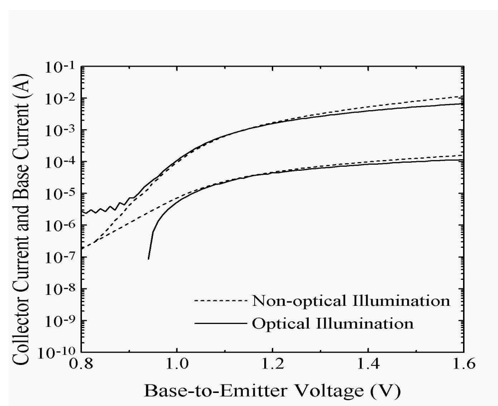

Fig.3 The measured Gummel plots for HBT/HPT under dark and optical illumination.

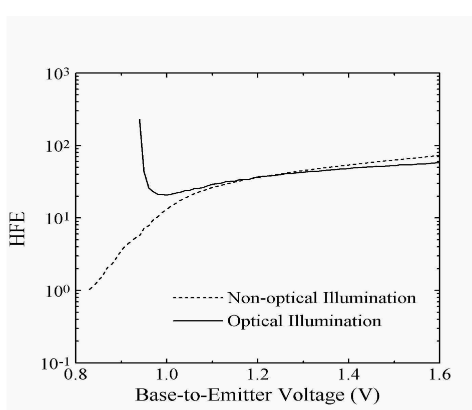

Fig. 4 The dc current gains as a function of the base-emitter voltage for HBT/HPT under dark and optical illumination.