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High-Efficiency and High-Power Ku-Band AlGaAs/GaAs HBTs

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AlGaAs/GaAs heterojunction bipolar transistors (HBTs) have demonstrated superior RF performances in microwave power applications[1,2,3]. Especially, the high power density capability results in great compactness for MMICs while their high efficiency at the class-B or class-C operation also decreases the prime power supply.

In this paper, we present multi-finger self-aligned HBTs producing 1W output power, 55% power added efficiency at Ku-band. The fabrication process is based on the original dummy emitter (WSi/SiON) bilayer technology.

The schematic view of the fabrication process and improved epitaxial structure of the HBTs are shown in Fig.1 and Table 1, respectively. The epitaxial layers were grown by MOCVD. To accomplish the reliability and the reproducibility, heavily C-doped base layer was employed. Moreover the base electrodes were formed in a self-aligned manner using the dummy emitter as a mask in order to reduce the base resistance. H^+ implantation was used for device isolation and reduction of base-collector capacitance. The increase of the parasitic capacitance was suppressed by air bridge interconnection of each collector electrodes. To reduce the thermal resistance, the substrates were thinned to 30 μm and the advanced plated heat sink (PHS) structure was adopted.

The β of 20-finger HBTs consisting of unit cell with emitter of $1.5\times20\,\mu m^2$ was more than 50 (Fig.2). The devices also exhibited a maximum collector current density of more than 150kA/cm^2. The f_T and f_{max} were 40GHz and 40GHz at the bias conditions of V_{CE}=2V and I_C=200mA, respectively (Fig.3). Figure 4 shows power saturation curves of the common emitter (CE) HBTs at 12GHz. High output power of 1W (output power density : 2.5W/mm) and excellent power added efficiency of 55% were realized at V_{CE}=7V. These are the highest values ever reported at Ku-band.

The high performance multi-finger HBTs for Ku-band high power MMIC amplifiers have been successfully developed. These above results are primarily attributed to the reduction of parasitic resistance and capacitance due to the self-aligned structure and the improvement of maximum current capability due to the PHS structure.

[1]B.Bayraktaroglu et al : IEEE Microwave Theory and Techniques, vol.38,No.10, p1381-1389,1990
[2]T.Shimura et al : Extended Abstracts of the 1991 International Conference on SSDM, p.77-79
[3]C.S.Wu et al : 1992 Proc. GaAs IC Symposium, pp. 259-262

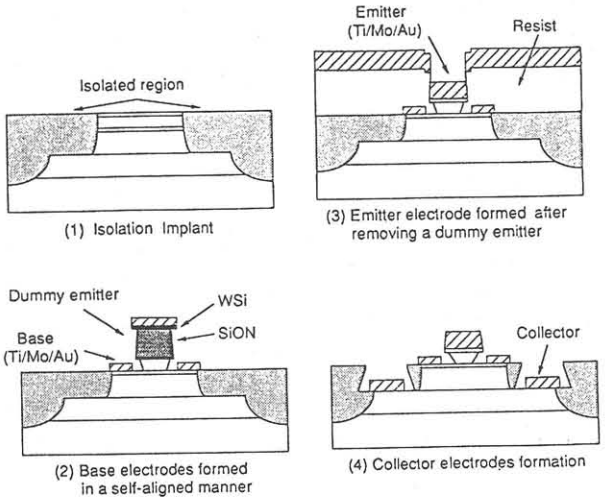

Fig. 1 Fabrication process of self aligned HBTs with a dummy emitter technique

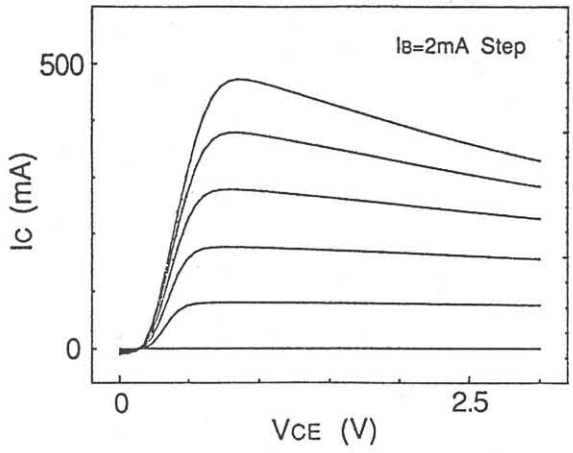

Fig.2 Ic-VCE characteristics for 20 finger HBT device ($1.5\times20\,\mu m^2\times20$)

Table 1. Epitaxial structure of HBT

Layer	AlAs fraction	Thickness (nm)
Cap	n^+-GaAs	100
Emitter	N-AlGaAs AlAs: 0 - 0.3 - 0	150
Base	p^+-GaAs	100
Collector	n -GaAs	500
Sub-collector	n^+-GaAs	500

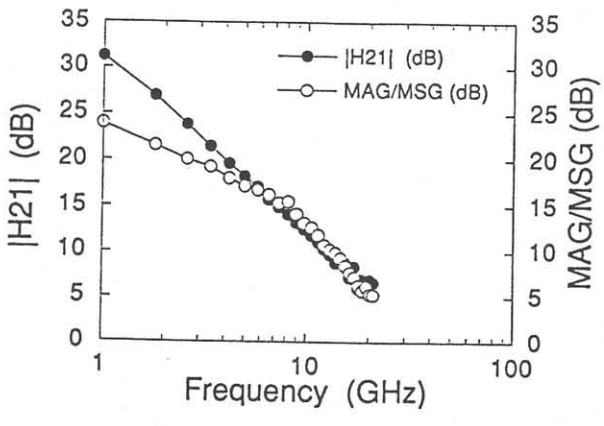

Fig. 3 |H21|, MAG/MSG vs frequency for 20- finger HBT device

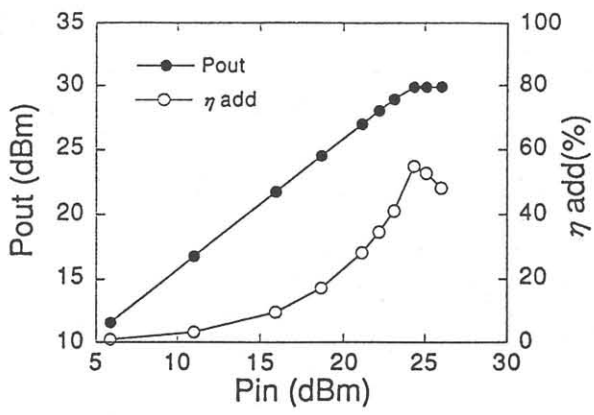

Fig.4 Power saturation curves of CE 20 finger HBT device at 12GHz