A Layout Practice of Die Size Reduction on InGaP/GaAs HBT MMIC for Handset Power Amplifier Application

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Abstract

InGaP/GaAs HBT has been widely used in power amplifier (PA) design for wireless communications due to its high linearity and high efficiency. The latest mobile devices, which offer the user mobile Internet and other multimedia services on the move, consume draw on far more data than previous generations of mobile phones. The volume of power amplifier in the smartphone is increased to require applying for GSM, UMTS and LTE applications with varieties of frequency bands for global roaming. The module size and cost of PA determine the competitiveness of products beyond the performance. This work present the 30% MMIC die size reduction by several layout approaches.

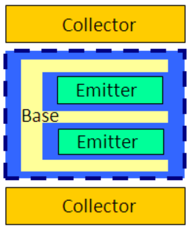
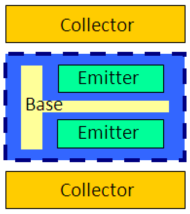
Increasing the flexibility of transistors layout can easily realize the multiband PA in a single MMIC GaAs die (Fig.2). Both horizontal and vertical emitter finger orientations (Table2) can be allowed for MMMB PA design (Fig.3). Besides the conventional HBT layout (Type-A HBTs), Type-B HBTs (Table1) perform higher maximum available gain (MAG) than Type-A HBTs within the operation frequency of mobile communications (Fig.1).

This work demonstrates a study of the device configuration’s optimization. A smaller size of unit cell, 3um*28um*3fingers is proposed instead of larger unit cell, 3um*40um*3fingers. The power cell composed by 3um*28um*3fingers unit transistor can deliver the same output power and ruggedness performance with higher gain and PAE comparing with the larger unit cell (Fig.4~5, Table3~4).

Besides the study of unit transistor, a more compact layout of dicing street and backside via is proposed in this work (Fig.6, Table5). Moreover, this work presented a

layout practice with 30% MMIC die size reduction on a multiband PA by implementing all approaches of die size reduction and flexible design of unit transistor (Fig.7, Table6).

Table 1
The illustration of Type-A and Type-B HBTs

Type-A HBTs	Type-B HBTs
	

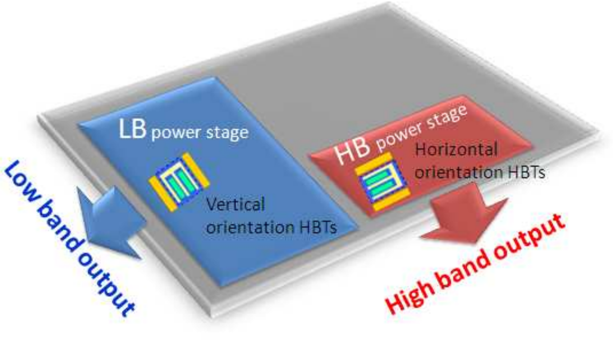


Fig. 2 The illustration of both horizontal and vertical orientation HBTs applying to Multi-Band PA.

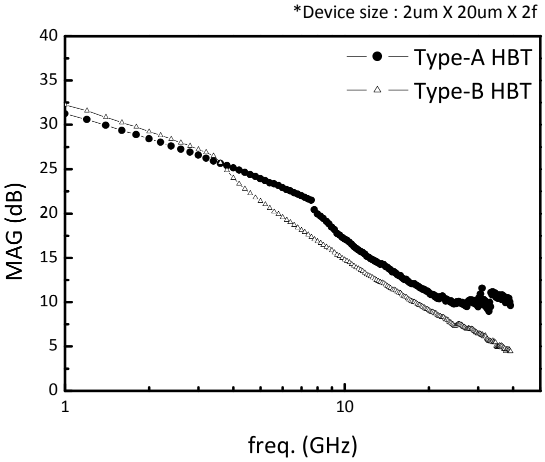


Fig. 1 The comparison results of Maximum Available Gain (MAG) between Type-A and Type-B HBTs. Type-B HBTs show higher MAG than Type-A HBTs for handset application.

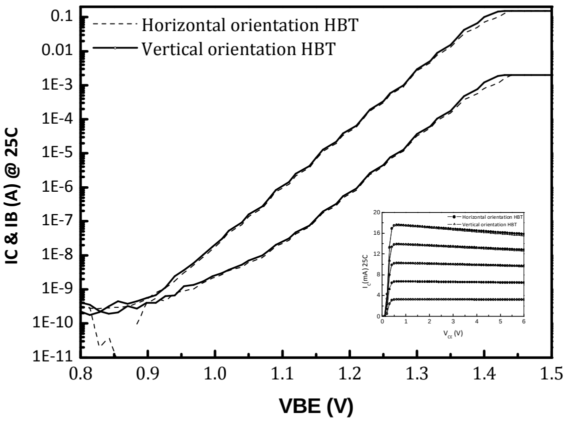
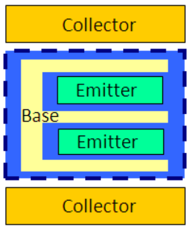
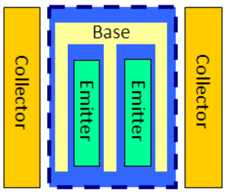


Fig. 3 The comparison results of Gummel Plot measurement between horizontal and vertical orientation HBTs. The DC characteristics between horizontal and vertical orientation HBTs are identical.

Table 2
The illustration of horizontal and vertical orientation HBTs

Horizontal orientation HBTs	Vertical orientation HBTs
	

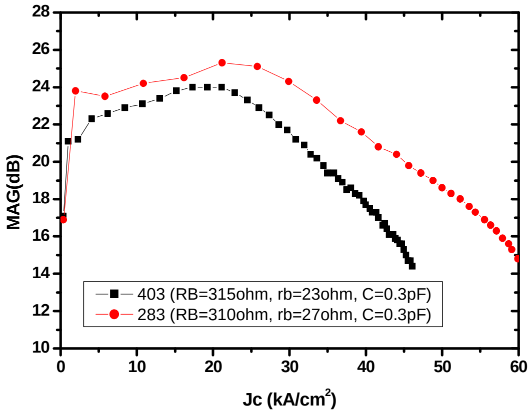


Fig. 4 The comparison results of Maximum Available Gain (MAG) between unit cell 3um*40um*3fingers and 3um*28um*3fingers. The device of 3um*28um*3fingers show higher MAG than 3um*40um*3fingers.

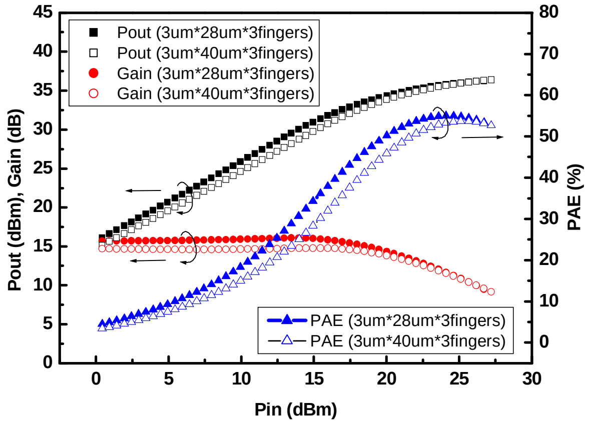


Fig. 5 The comparison results of power performance between unit cell 3um*40um*3fingers and 3um*28um*3fingers.

Table 3
The comparison of the emitter area of power cell.

Device	Unit transistor configuration	# of fingers	Total area
Power cell-A	3um*40um*3fingers	96	11520 um^2
Power cell-B	3um*28um*3fingers	96	8064um^2

Table 4
Ruggedness test results

Device	Total area	VCE	Pout	VSWR		
				10:1	20:1	50:1
Power cell-A	11520 um^2	3.6V	35 dBm	Pass	Pass	Pass
		5V		Pass	Pass	Pass
Power cell-B	8064um^2	3.6V		Pass	Pass	Pass
		5V		Pass	Pass	Pass

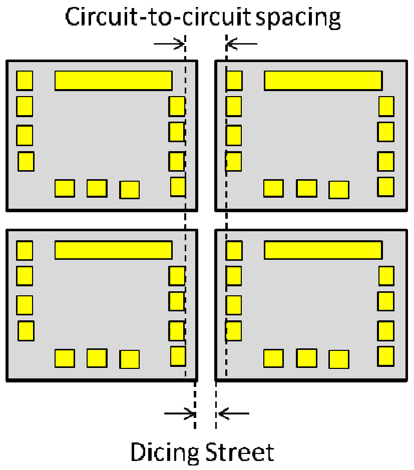


Fig. 6 The illustration of dicing street structure

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Table 5
The comparison of dicing street dimension.

	Dicing Street	Ckt-Ckt spacing
Sawing dicing	58um	80um
Laser dicing	40um	50um

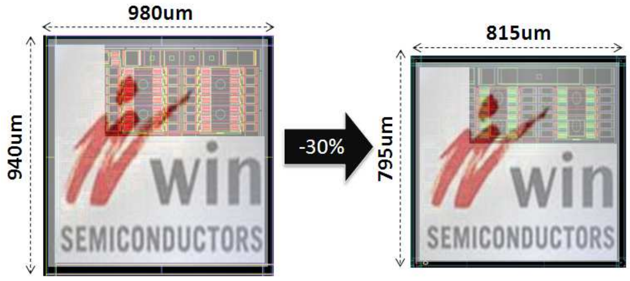

Fig. 7 The layout practice of die size reduction.

Table 6
The comparison of MMIC area.

Device	Width	Length	Total area
MMIC-A	980um	940um	0.92 mm^2
MMIC-B	815um	795um	0.65 mm^2