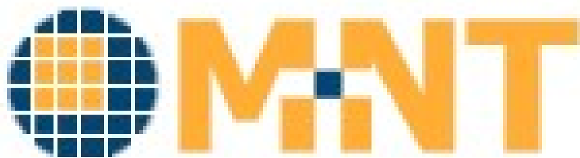
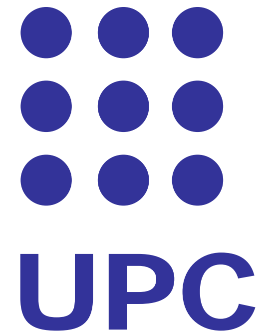
Numerical Modeling for Comparison of Emitter-Base Designs of InGaP/GaAs Heterojunction Bipolar Transistors

Juan M. López-González

Micro and Nano Technologies Group,
Centre for Research in NanoEngineering,
Universitat Politecnica de Catalunya,
Barcelona, Spain



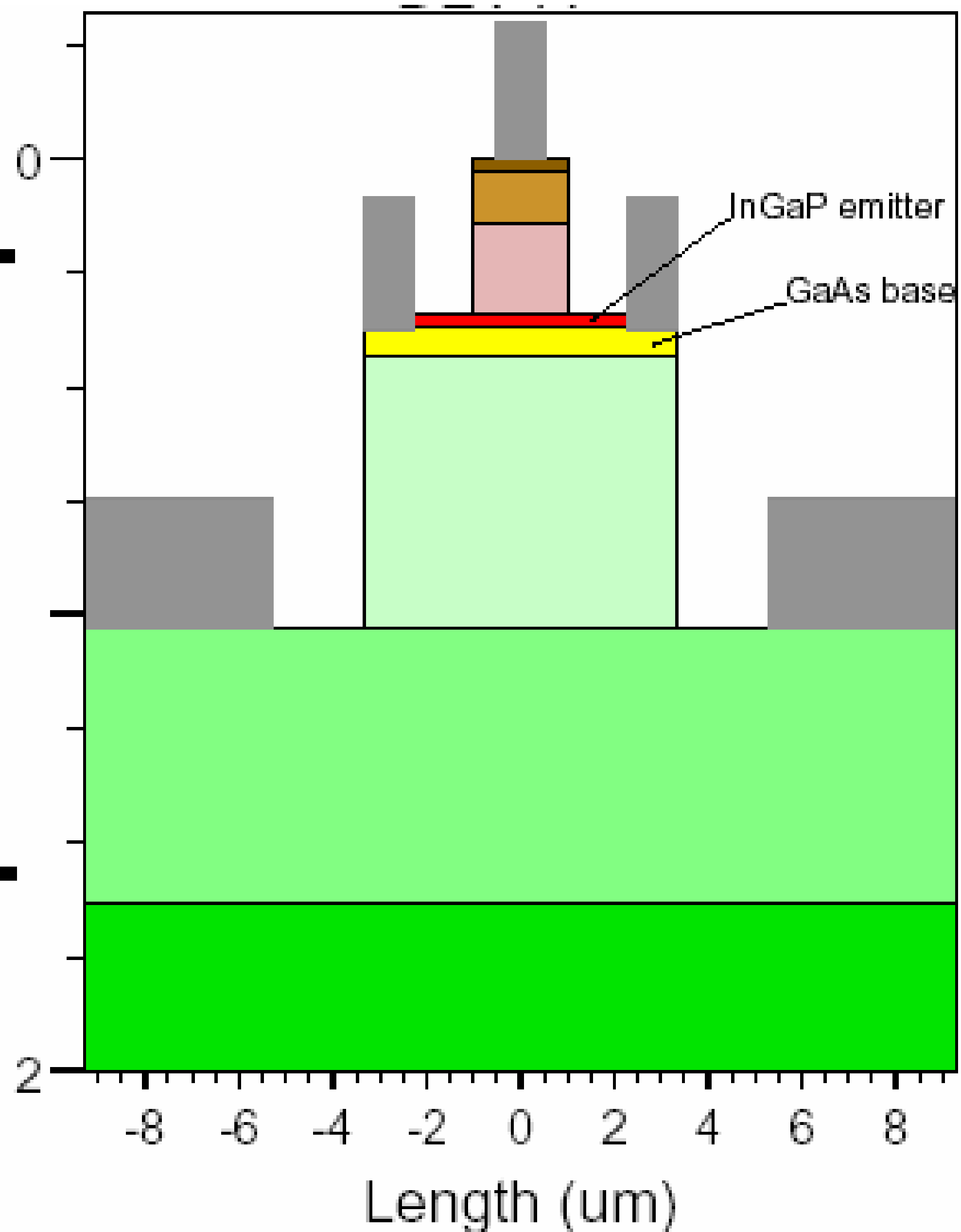


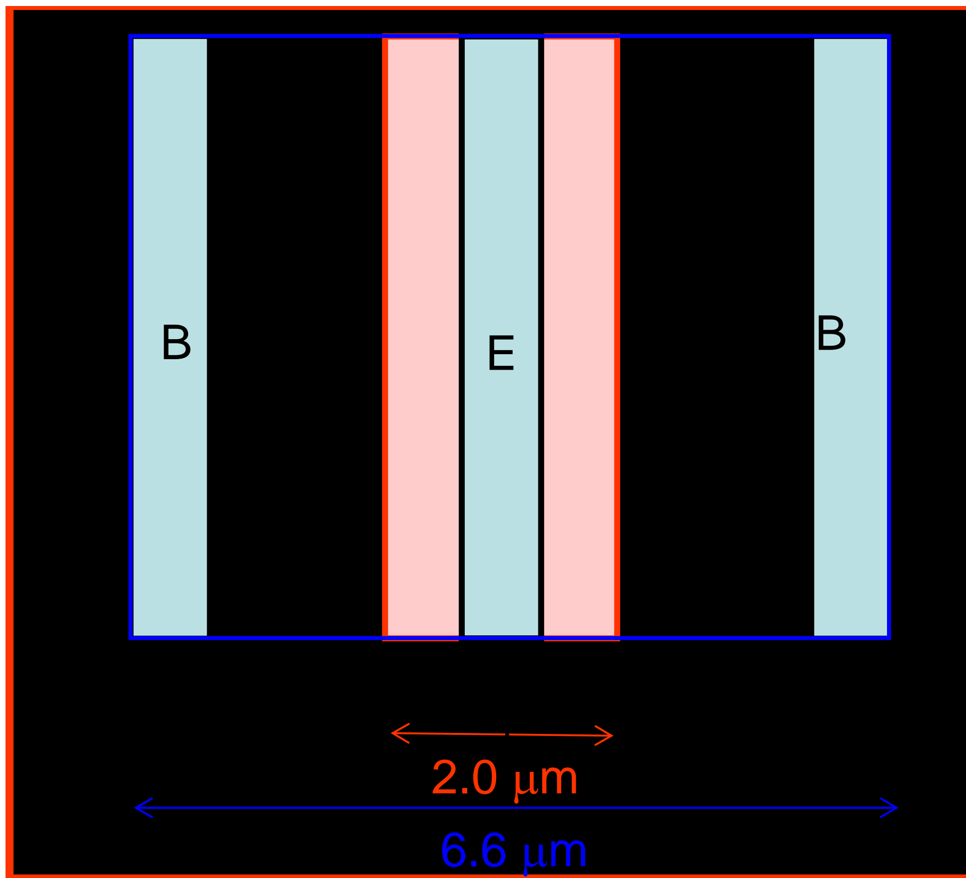
This work describes the DC and small-signal performance of two InGaP/GaAs Heterojunction Bipolar Transistors, HBTs, which have the same chip size, in order to compare emitter-base designs, using TCAD device simulator ATLAS.

The HBT devices analyzed have the same cutoff frequency and maximum frequency, 94 GHz and 84 GHz, but differences are observed in other characteristics as base-emitter turn-on voltage, saturation collector-emitter voltage, maximum forward current gain and maximum transducer power gain.

MATERIAL	THICKNESS(Å)	DOPING (cm^{-3})
n-InGaAs	300	1e19
n-GaAs	1100	1e19
n-GaAs	2000	2e17
n-InGaP	300	4.5e17
p-GaAs	**600**	**4e19**
n-GaAs	6000	1.5e16
n-GaAs	6000	3e18
Sust.-GaAs	-	-

Table 1: Doping profile of NPN InGaP/GaAs HBTs.

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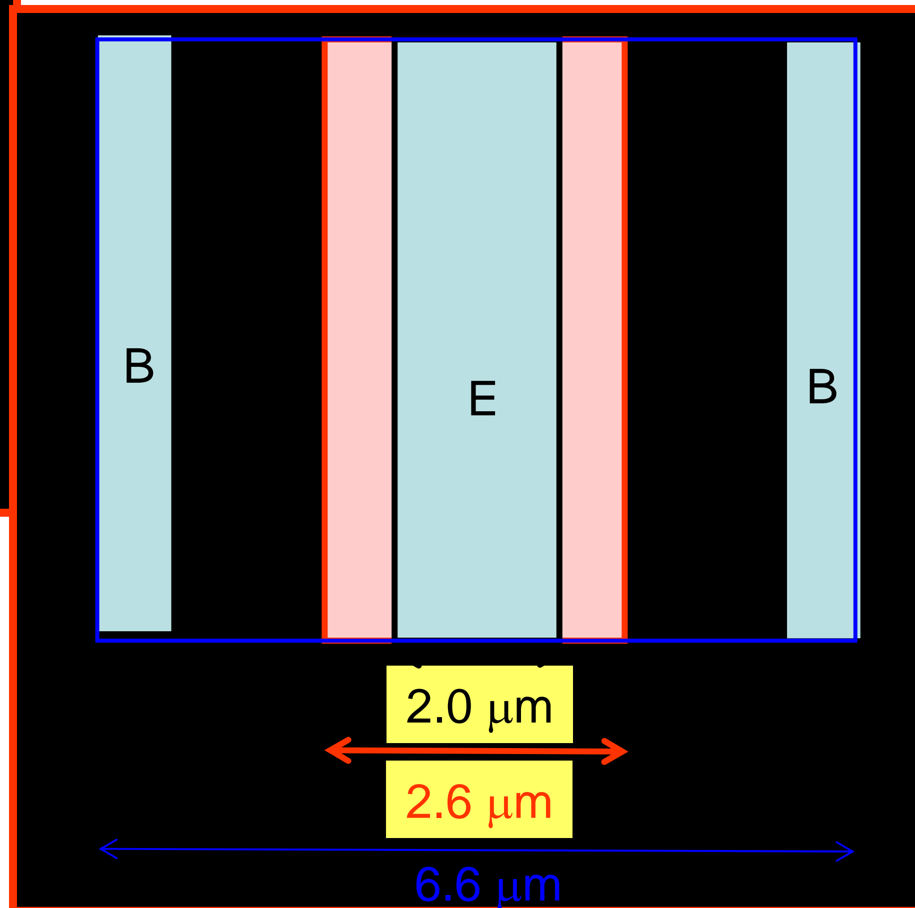
6.6 μm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	GaAs	GaAs	InGaP	GaAs-p	GaAs	GaAs
Eg (eV)	1.42	1.42	1.84	1.42-0.07	1.42	1.42
χ (eV)	4.07	4.07	3.93	4.07	4.07	4.07
ε_r	13.2	13.2	12.5	13.2	13.2	13.2
Nc (10^{17} cm^{-3})	4.5	4.5	8.4	4.5	4.5	4.5
Nv (10^{19} cm^{-3})	1	1	1	1	1	1
μ_n(cm^{2}V^{-1}s^{-1})	1600	3000	850	1200	4000	2000
μ_p(cm^{2}V^{-1}s^{-1})	100	200	70	60	200	120
τ (10^{-9} s)	0.5	1	0.5	0.05	1	1

Table 2: Material parameters used in the simulation of the InGaP/GaAs HBTs.

	DEV-A	DEV-B	
$\beta_{F,max}$	160	100	
$V_{CE,offset}$	0.12	0.1	Ic@5mA
$V_{BE,on}$	0.92	0.9	Ic@1nA

Table 3: DC performance of the InGaP/GaAs HBTs.

2.5 GHz	DEV-A	DEV-B
K_{Stern}	0.15	0.20
h_{fe} (dB)	37.4	37.8
GU (dB)	33.5	33.7
G_{mT} (dB)	36.2	34.3
MSG (dB)	25.3	27.2
Input Loss (dB)	-1.34	-2.50
Output Loss (dB)	-1.28	-2.26
Forward Gain (dB)	24.5	26.8
Reverse Isolation(dB)	-26.2	-27.5

Table 4: AC performance of InGaP/GaAs HBTs at 2.5 GHz.

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jmlopezg@eel.upc.edu

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Micro and Nano Technologies Group,
Centre for Research in NanoEngineering,
Universitat Politecnica de Catalunya,
Barcelona, Spain