

COMPARISON OF GaAs FET AND Si HIGH FREQUENCY RF FAMILY FOR DESIGN OF LOW NOISE AMPLIFIER USING BJT

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ABSTRACT: *In wireless communication the most precious block is LNA and its design to catch the optimum noise figure with faithful gain. So for getting the desired terms with considering the cost we should compare the formation of LNA using BJT with different Transistor Families with their essential characteristics so for that here we are trying to conclude some precious characterizing comparison of BJT with GaAs FET AND Si materials with their fundamental properties in the admirable pattern for the design point of view in the LNA formation for the RF Front End.*

I. INTRODUCTION:

As nowadays the RF Front End Technology gets upgraded drastically in the form of design of Low Noise Amplifier. For the improvement of the noise figure we are using LNA devices by using various High Frequency components, As one of the major suppliers in the area of High Frequency (HF) components, the Siemens semiconductor HF Product Division stands for a continuous commitment to innovative Technologies and Products combined with volume strategy.[1] The Siemens Technology and Product Roadmap is directed to complete RF system solutions and device kits as well as standard and custom specific components in enhanced Si, GaAs and Hetero Materials(SiGe HBT, GaAs HEMT, GaAs HBT). A core competence is the fabrication of RF components in Surface Mounted Technology (SMT). High volume discrete in Si & GaAs, MMICs (Monolithic Microwave IC's) in Si & GaAs, and finally Fast Logic Circuits in enhanced Si technologies.[2]

II. TECHNOLOGIES

The various RF component using various microwave transistor family should be characterized in detail The MESFET still is the working horse GaAs technology. It is mostly based on ion implantation into semi insulating substrates. This is the least expensive process concerning raw material cost, since no epitaxial layers are required. The technologies on the market are processed with gate length from 0.8 μ m down to 0.25 μ m. fT values in the range of 25GHz are available in production dependent. The advanced performance silicon bipolar processes with the fT up to 25GHz are processed on refined high performance IC technology lines.

Standard feature sizes of 0.4 μ m emitter width in double poly self aligned technique, side wall spacer technique, buried layers, selective implanted collector are build into these highly sophisticated devices. Even more advanced technologies with further shrieked emitter widths are available with fT up to 45GHz (Siemens B6HFE). [6]

One of the biggest advantages of the Si processes is the potential to use the high integration capability of Si. Not only in highly integrated bipolar only circuits, but also the combination with CMOS technology . The SiGe HBT (fig. 2e) is a further improvement of the Si advanced bipolar process. The base layer is replaced by a hetero SiGe layer. In the Siemens B7HF process the minimum feature size is 0.25 μ m and the AlSiCu metallization are replaced by 4 layer copper metallization. The process has an fT of 75GHz and is fully compatible to standard CMOS. The other processes for low noise applications show fT in production from 60 to 70GHz. To serve also power applications higher breakdown mechanism. High frequency switching devices are mainly manufactured for the purpose to avoid transit time effect for the perfect utilization of power factor improvement process. The process of epitaxial growing for the use of high Gain-Bandwidth product in the design of Low Noise Amplifier production technology. There are also some criteria for which there are some compensation technique should be used to overcome the over all performance of the detailed parameter analysis.[7] The use of various technology for the implementation of the high frequency devices are utilized for the same advancement criteria[2]

**III. CHARACTERIZATION
COMPARISON ON PERFORMANCE BASIS.:**

A.Front End:

From Figure 1.:The f_T of this high-frequency(HF) SiGe device is much higher than the f_T of this high frequency(HF) Si device However, the f_T of this high voltage(HV) SiGe device is comparable to the f_T of this high-voltage (HV) Si device. This GaAs device has a higher breakdown than these Si and SiGe devices →Good for PA survivability to mismatch. PNP and FETs are main attraction of Si and SiGe technologies →Increased PA functionality.[3]

B.Back End:

From Figure 2.:The Si and SiGe technologies have a higher thermal conductivity than the GaAs technology →Can help ruggedness (PA survivability to mismatch), but die must be sufficiently thinned These Si and SiGe devices experience quasi-saturation at higher current densities →Bad for linearity.

SiGe will result in only minor improvements concerning the known cellular and cordless phone systems, i.e. will not substitute any Si Bipolar circuit due to higher cost. A key question is whether the material benefits justify the realization of 1-chip UMTS transceivers. Moreover, the main potential is for receivers at higher frequencies (2-20GHz). -- GaAs HEMT technology is the best MMW material upto 100GHz. It combines the advantages of unipolar transistors with outstanding performance down to 1.5V supply, but with a factor 2 higher wafer cost compared to GaAs MESFET.[4]

The GaAs HBT process is a candidate of a single supply voltage. Disadvantage to GaAs MESFET and HEMT are reduced shrink potential due to thermal problems ,reduced linearity of bipolar transistors and cost levels

compared to HEMT. It could be argued that these Si and SiGe devices should achieve higher PAE than this GaAs device since they do not have a VCE offset.

These GaAs devices should provide more gain per stage than these Si or SiGe devices. BJT requires 0.07 V more than the emitter-base voltage. This reduction in turn-on voltage is caused by a decrease in the barrier height for injection of electrons. It is possible to reduce the power dissipation in the circuit environment. On the other hand, due to the smaller band gap in the base, the high temperature range is going to be more restricted than in Si. The mobility is computed using Bufler *et al.*, data. They have reported that minority carrier mobility in unstrained and strained Si_{0.88}Ge_{0.12} are different as in the case of Si BJT.[5]

C.Graph and Tabular Analysis:

Here we can analyze the overall material based analysis by study the following graphs.

Device Level f_T Characteristic:

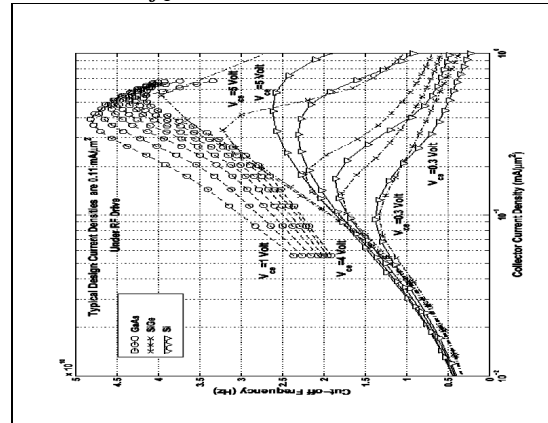


Figure 1.: f_T Characteristic:

Device Level $I_c - V_{ce}$ Characteristic:

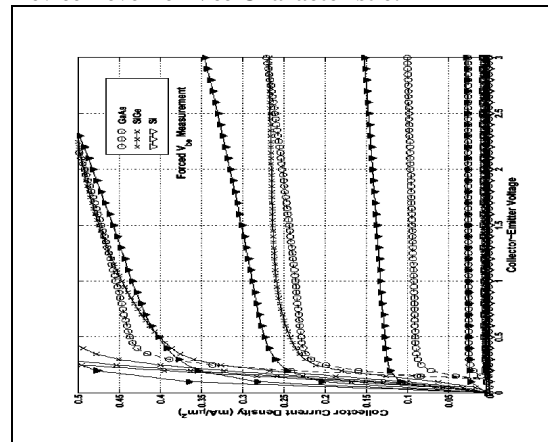


Figure 2.: $I_c - V_{ce}$ Characteristic:

IV. PERFORMANCE ANALYSIS:

Parameter	GaAs based Technology			Si based Technology	
	MESFET	HEMT	HBT	Si BJT	SiGe HBT
Gain	Good	Best	Best	Best	Moderate
Power <0.5W	Best	Best	Best	Best	Best
>2.0W	Best	Best	Best	Good	Good
Efficiency	Good	Best	Good	Moderate	Moderate
Low Voltage	Good	Best	Good	Good	Good
LF<100 MHz	Moderate	Moderate	Good	Best	Best
RF 2GHz	Best	Best	Best	Good	Good
RF 10GHz	Good	Best	Good	Good	Moderate
Power Supply	Good	Good	Best	Best	Best

From the above table we can analyze the device level performance so that we can concentrate on improved gain as well as the noise figure analysis in the desired criteria so while designing the LNA using BJT which is really cost effective the recent market demand on the required level characteristics so that on the fulfillment of the product establishment features.

As we can say that we should also emphasize on the compromise base terminology for the every product features on the optimum level.[8]

So for the thinking in the positive direction we can get the uplifting of the on the way device level judgmental view for the design based on low noise amplifier by using the bipolar junction transistor families which can emphasize on more solid state analysis.

The performance analysis chart shows the characteristics advantage and disadvantage depending upon the frequencies standard so we can judge that the solid state device characteristics gives us the different snapp off time which is analyzed in step recovery diode which is used in the microwave transistor families.[9]

so we can use the overall minority charge life time study how they can give us the perfect criteria of the general show fall of the high frequency compatibility of the devices so we can judge the desired level characteristics according to the perfect microwave compatibility. [10]

V. CONCLUSION:

In this paper we re trying to characterize the overall performance analysis of solid state material like GaAsFET and Si based Bipolar Junction Transistor Families on the bases of Microwave Frequency compatibility and trying to find out the optimum resolution for the design of Low Noise Amplifier design point of view .This GaAs HBT has a higher BVCEO than these Si or SiGe devices and should be more rugged. These Si and SiGe devices do not have VCE offsets and should be more efficient than this GaAs device. This GaAs HBT has a higher fT than these Si or SiGe devices and should provide more gainper stage. SiGe technology is making tremendous progress in providing solutions traditionally offered only by GaAs technologies and at a lower cost, the two technologies should be considered complementary.

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