Low Voltage Class C SiGe Microwave Power HBTs

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Abstract: The structure and microwave characteristics of low-voltage SiGe power HBTs are given. With this structure, the device can operate in a low-voltage and high-current state. By using an interdigital emitter strip layout and the operating voltage ranging from 3 to 4V, the output power in Class C operation can reach 1.65W at 1GHz, with the gain of 8dB. The highest collector efficiency is 67.8% under 3V.

Key words: SiGe; HBT; microwave power transistor
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1 Introduction

Due to the application of SiGe material, the heterojunction conception is introduced into the silicon process. Thus, the design restrictions of the conventional silicon bipolar transistor can be overcome. For example, the highly doped base is employed while the acceptable current gain is kept constant, as is very important, especially to the application of power transistors.

SiGe HBTs in power applications have been intensively investigated recently.\textsuperscript{[1-4]} In wireless communications, especially the mobile phones, the battery’s circuit is desired to operate in a low voltage of 3V around. In this paper, the low voltage class C SiGe power HBTs are adopted as the transmitter in wireless communications.

2 Device

The device’s structure is shown in Fig. 1. The SiGe base and Si emitter are epitaxied by using our self-developed HV/RTCVD equipment. The base is doped by boron to $8 \times 10^{19} \text{cm}^{-3}$, and has the 20% fraction of Ge. Its thickness is 100nm. The emitter is doped by phosphorous to about $2 \times 10^{18} \text{cm}^{-3}$.

\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{fig1}
\caption{Structure of Mesa-Type Microwave SiGe HBT}
\end{figure}

Mesa-type device has been adopted to fabricate the HBTs. The power HBT, having an interdigital structure, has 80 emitter strips, each of which is 2μm wide and 20μm long. The process has been published in details before.\textsuperscript{[4]}

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JIA Hong-yong PhD candidate. Now he is interested mainly in the research on SiGe material growth, characterization and its application in microwave HBT devices, including low noise and power applications.

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3 Results

Figure 2 shows the output characteristics of a power transistor. The current gain is deduced to be more than 50.

![Typical Output Characteristics of SiGe Power HBT](image)

FIG. 2 Typical Output Characteristics of SiGe Power HBT. x axis is $V_o$ in 0.5V/div; y axis is $I_o$ in 50mA/div; k step is 1mA.

Figure 3 shows the measurement results of the microwave power. At 1GHz and the test circuit being biased in class C operation, the device is matched at the input power of 0.2W for the highest gain. Then, the input power varies. The highest output power is 1.65W under the $V_o$ of 4V; while, without any re-matching, it is 1.2W when the $V_o$ is decreased to 3V. We are convinced that matching the device can generate more output power.

![Primary Microwave Power Measurement Result](image)

FIG. 3 Primary Microwave Power Measurement Result

Figure 4 is the relationship between the collector efficiency variations and the collector voltage. Same as before, the measurement points are obt-

![Collector Efficiency Under Unmatched Conditions](image)

FIG. 4 Collector Efficiency Under Unmatched Conditions. The highest efficiency is 67.8% under 3V.

4 Conclusion

The low voltage power SiGe HBTs that are suitable for the mobile communications have been demonstrated. The SiGe material has been grown by using the self-developed HV/RTCVD method. The primary characteristics are presented. Under the working voltage of 3 to 4V, the output power is obtained more than 1W, and the collector efficiency is more than 60%.

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References

低电压 C 类 SiGe 微波功率异质结双极型晶体管

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摘要：给出了低电压微波 SiGe 功率异质结双极型晶体管 (HBT) 的器件结构和测试结果。器件结构适于低压大电流状态下应用，采用了梳状发射极条的横向版图设计，其工作电压为 3—4V。在 C 类工作状态，1GHz 的工作频率下，输出功率可以达到 1.65W，具有 8dB 的增益，3V 时可以达到的最高收集极效率为 67.8%。

关键词：锗硅；异质结晶体管；微波功率晶体管

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贾宏勇 博士研究生，主要研究兴趣为 SiGe 材料的生长、表征及其在微波 HBT 器件中的应用。

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