Uniformity improvement of SiGe HBT by reduced extrinsic base implanted damage

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1. Introduction

HBT with non-selective SiGe has been promisingly demonstrated for wireless communication. As the emitter window size and the lateral extrinsic/intrinsic base shrink, the defects associated with the extrinsic base implantation will increase extrinsic base resistance \(R_{\text{ex},(b)}\) and base to collector capacitance \(C_{\text{bc}}\), both of which degrade the device performance and uniformity. In this paper, we used seed layer implantation prior to forming the epi-base with an additional rapid thermal annealing to reduce extrinsic base damage caused by the implantation. In comparison with conventional extrinsic base implant process, devices with a significant improvement of uniformity and yield were achieved.

2. Device Fabrication

A conventional structure of a non-selective SiGe HBT is shown in Fig. 1(a), where the graded \(\text{Si}_x\text{Ge}_{1-x}\) \((x=15-0\%)\) layer sandwiched by \(\text{Si}_{0.4}\text{Ge}_{0.6}\) spacer and Si cap layer was epitaxially deposited in a hot-wall UHV/CVD system at 550°C. The pure silane (\(\text{SiH}_4\)), germane (\(\text{GeH}_4\)) and diborane (\(\text{B}_2\text{H}_6\)) diluted in He are introduced as the gas source. The detail process can be obtained from our previous report [3]. Fig. 1(b) shows the TEM image of conventional non-selective SiGe HBT. Severe implantation-induced defects are found between the poly emitter and seed layer region (EB). The new approach shown in Fig. 2 has a seed layer implant prior to the SiGe base formation.

3. Device Characterization

Fig. 3 shows the Gummel plot of the transistors made by conventional extrinsic base implantation and the new approach. The transistors have an emitter of 0.6x10 \(\mu\)m\(^2\). An extremely low base-recombination current \(I_B\) of 0.3 \(\mu\)A and low 2\(KT\) current were obtained from the new approach devices, indicating that few damage-induced defects were created in the extrinsic base region. Histograms of collector current \(I_C\) under \(V_{\text{BE}}\) of 0.66V for both extrinsic base implantation and the new approach are shown in Fig.

4. Conclusion

We use seed layer implantation prior to forming the epi-base with additional rapid thermal annealing to reduce extrinsic base damage caused by implantation. A significant uniformity improvement of collector current and devices with high-yield performance were achieved.

Reference

Fig. 1 Schematic (a) and TEM (b) of the non-selective SiGe HBT with extrinsic base implantation.

Fig. 2 SiGe HBT with the seed layer implant prior to the formation of epi-base.

Fig. 3 Forward Gummel plot of SiGe HBT with emitter area of 0.6x10μm².

Fig. 4 Histograms of I₉ at V_BE=0.66V for both extrinsic base and new approach implantation devices.

Fig. 5 Current gain of the SiGe HBT versus seed layer RTP annealing temperature.