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Hf noise improvement of SiGeC HBTs by base doping optimization

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ABSTRACT. SiGeC heterojunction bipolar transistors (HBTs) have proven in recent years to offer additional engineering possibilities to achieve high maximum transit frequencies F_T, high F_{max} and low noise. Here we describe the optimization of the base layer doping in our 0,35µm SiGe-BiCMOS technology to achieve minimum HF and 1/f noise figures.

EXPERIMENTAL. The SiGeC base layer is deposited by RT-CVD-epitaxy enabling specific base engineering. The epitaxial layer consists of an undoped buffer, the bipolar base layer with B- doping and a Ge-ramp and a cap layer (Fig.1). In order to optimize NF_{min} and F_{max} the base resistance has to be minimized. The sheet resistances of the extrinsic base, the link region and the intrinsic base have been reduced by introducing additional B-doping. Investigations of different profiles for the cap layer have shown, that an additional B-peak at the emitter side and the increase of the spacing layer between cap peak and base gives the best results with respect to low base sheet resistance and low total emitter base capacitance.

Profile	B-peak conc	Max Ge-conc	Buffer
A	1x	1x	Thin
B	2x	1x	Thin
C	2x	1x	Thick
D	2x	1,5x	Thick

Table 1: base profile variations

The investigated variations of the base profile are summarized in table 1. In addition to a low base resistance a high bipolar gain is targeted to achieve low 1/f noise. It is shown, that a higher F_{max} can be achieved by increasing the height of the B-peak in the base (Fig 2/3 A to B). A trade-off is the decrease of F_T due to base widening because of enhanced B-diffusion. A thicker buffer layer increases F_{MAX} indicating an insufficient conductivity of the link region with a thin base layer. F_T decreases again due to an enhanced base collector transit time through the thicker buffer (Fig. 2/3 B to C). The loss in F_T can be compensated by a higher max Ge-concentration that leads to a higher effective electrical field within the neutral base (Fig. 2/3 C to D). It is noteworthy that the current gain of the different profiles correlates strongly with the maximum transit frequency F_T.
The base resistances of profile A and D extracted from DC noise measurements are shown in Fig 4. The DC base resistance reduces by more than a factor of 2, while the HF noise figure has been considerably improved to NF_{min} < 0.6dB at 2GHz for the new profile D. This is the lowest minimum noise figure reported for a 0,35µm technology enabling high performance low noise RF-applications.

CONCLUSION. In order to optimize a SiGeC HBT base engineering of the base doping has been performed. R_B could be reduced successfully resulting in high F_{max} and excellent low HF-noise performance.

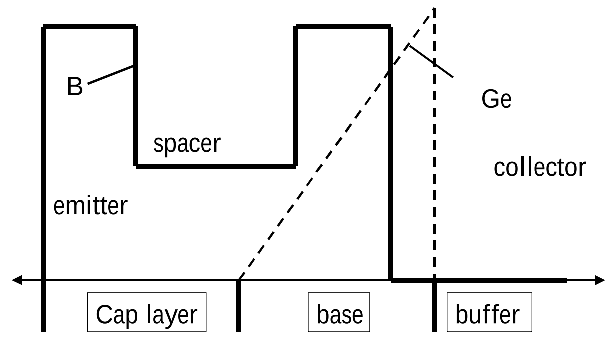

Figure 1

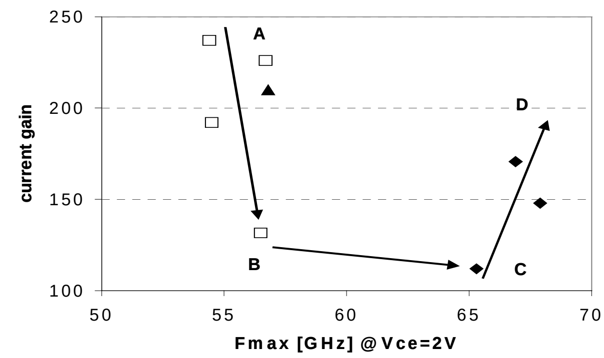

Figure 2

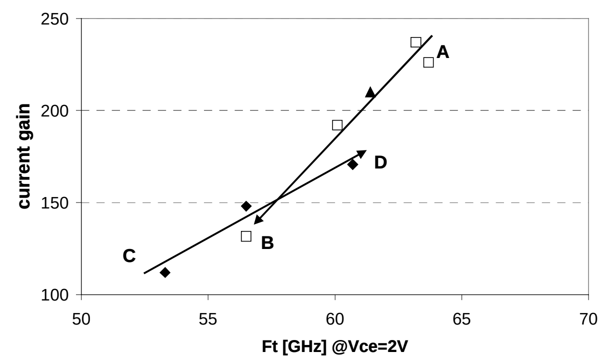

Figure 3

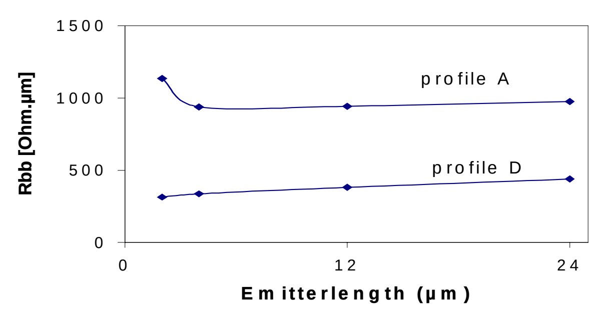

Figure 4

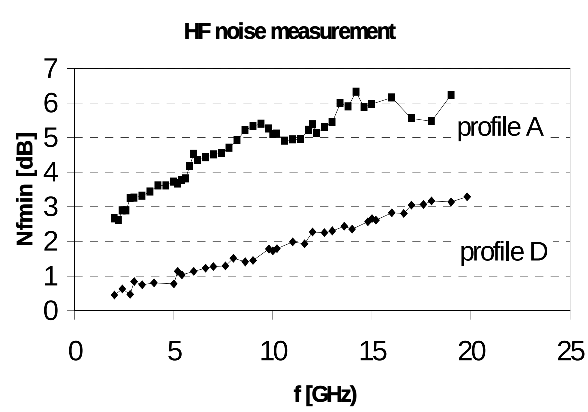

Figure 5