Current Gain in SiGe HBTs

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Bipolar Arbeitskreis, Rev. 1.0

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Introduction

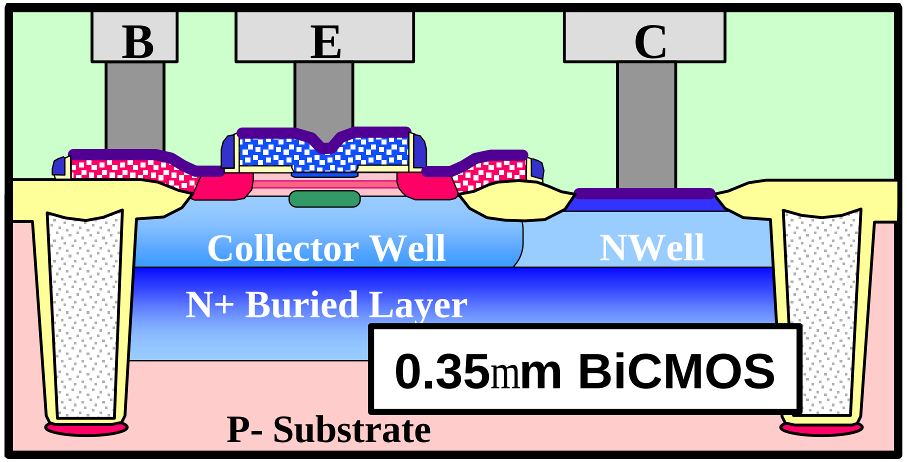
- Application of SiGe HBTs in power devices
  - **d β/dT < 0 ➔ no „thermal runaway“**
- Current gain dependent on Ge profile in base

WHAT ABOUT dβ/dT ?

- SiGe HBTs with different positions of B doping peak relative to Ge profile
  - **Analytical calculations, process / device simulations**
  - **Comparison with measurements on MOTOROLA CDR1-SiGe HBTs**

0.35mm BiCMOS: HBT Structure

HBT Parameter	0.35mm
Beta	120
Early Voltage (V)	95
BV_{CEO} (V)	3.4
f_T @ 2V (GHz)	49
f_{MAX} @ 2V (GHz)	86
J_C @ Peak f_T/f_{MAX} (mA/μm^2)	1.5
NF_{MIN} @ 2GHz (dB)	0.9
Minimum W_E (μm)	0.4
Intrinsic Base R_S (Ohm/sq)	1.9k



- Deep Trench/PELOX
- N+ Buried Layer
- Non-selective SiGe:C epi
- QSA Emitter/Base Structure
- As In-situ doped Emitter

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Analytical Calculation

- Start with generalized Moll-Ross relation from Kroemer

$$J_C = \frac{q\left(e^{\frac{qV_{BE}}{kT}} - 1\right)}{\int_0^{W_B} \frac{N_B(x)\,dx}{D_{nB}(x)\,n_{iB}^2(x)}} = J_{C0}\left(e^{\frac{qV_{BE}}{kT}} - 1\right)$$

- Assume identical iB ➔ Temp. dependence of Jc0 allows to visualize changes in dβ/dT

Analytical Calculations

- Use data for:

  Ge profile

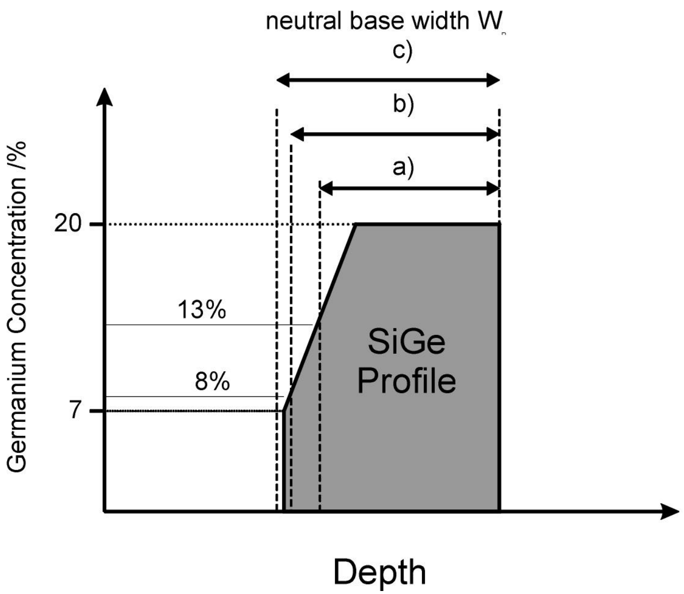
  $\mathbf{N_B(x)}$

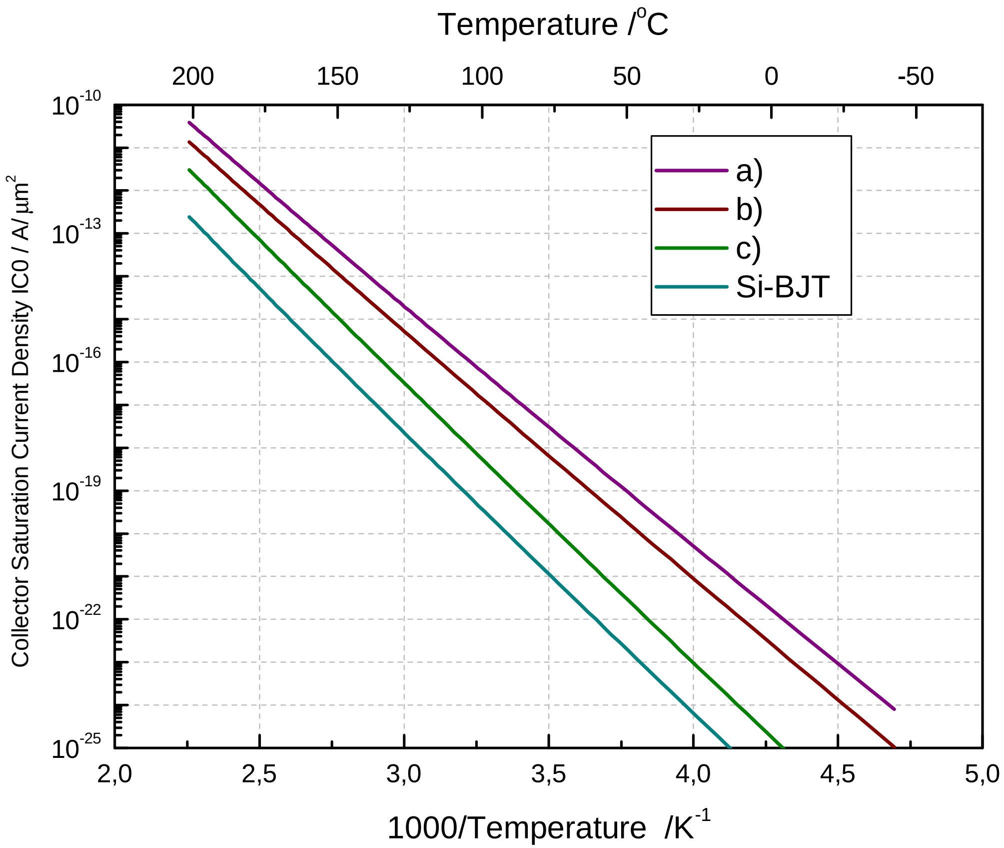
  $\mathbf{D_{nB}(x) \rightarrow \mu_n(x)}$

  $\mathbf{n_{iB}(x) \rightarrow E_g(x), N_c(x), N_v(x)}$

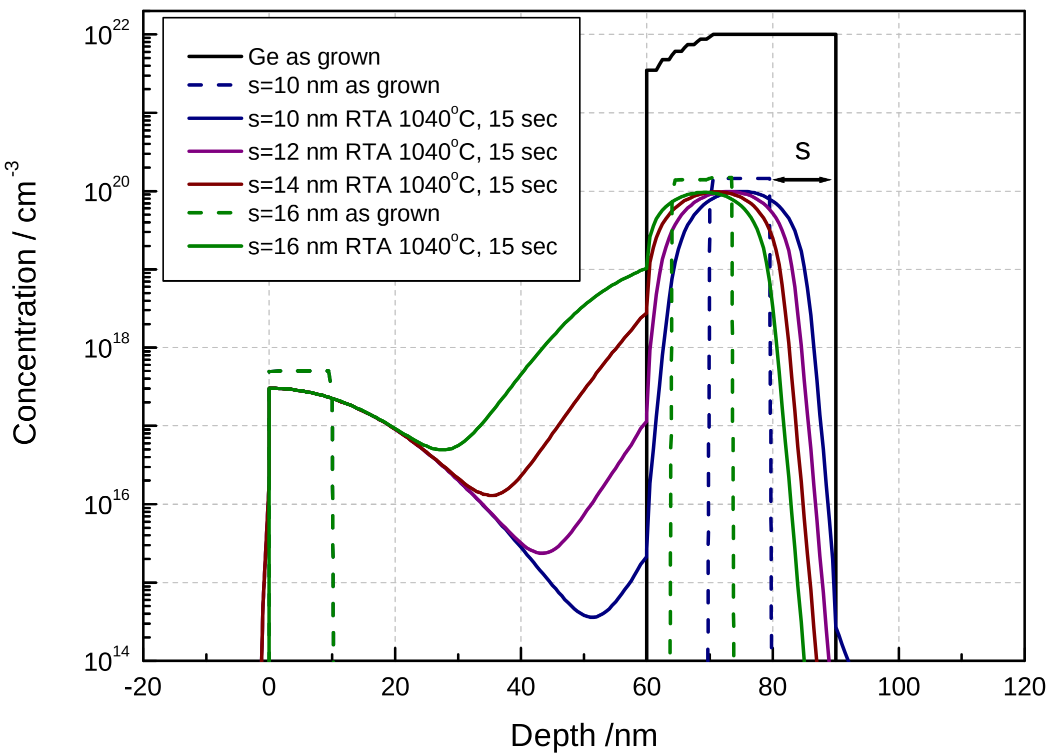
  from technology / literature

Collector Saturation Current

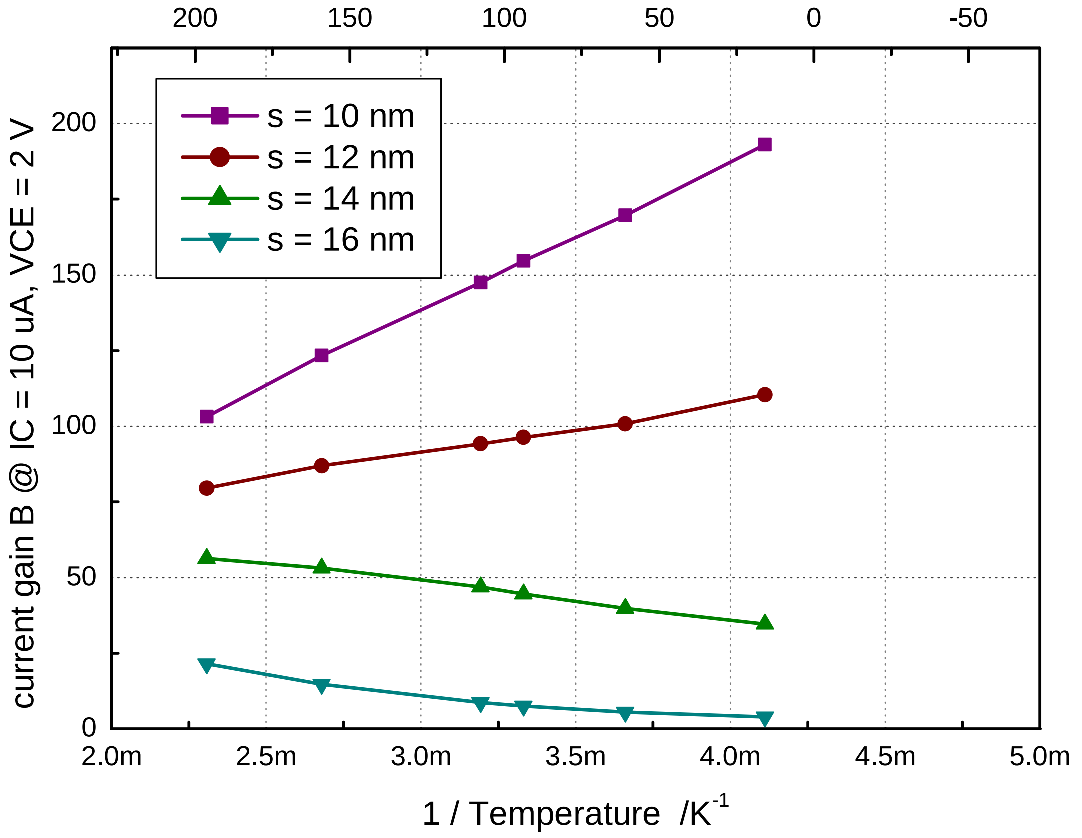




Process Simulation



Device Simulation



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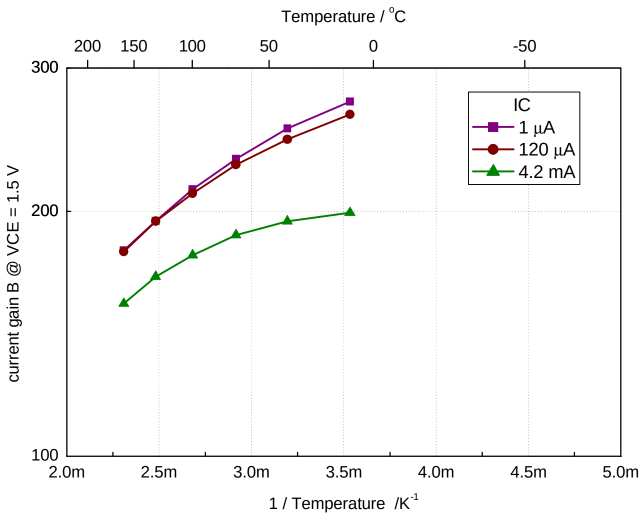
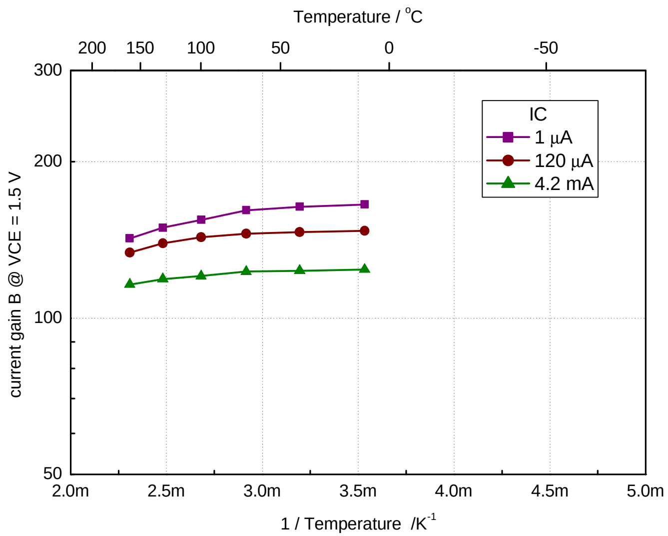
Measurement Results

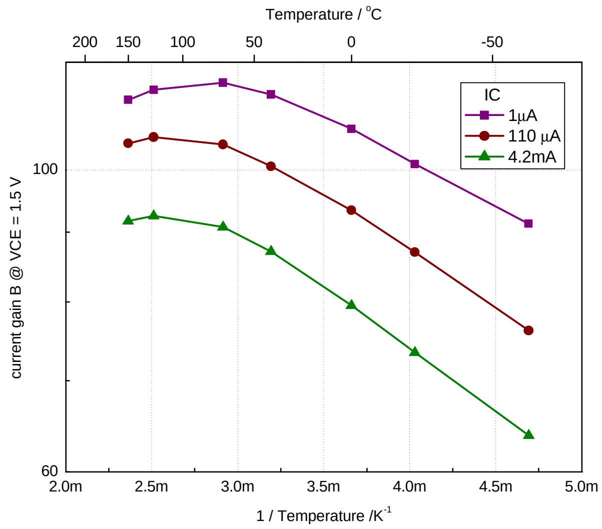
a) Base fully in Ge



b) Base edge close to Ge edge



c) Base edge in Si



Measurements vs. Analytical Calculations