High Germanium Content Devices: Structure, Physics, Applications

E. Kasper, M. Oehme, M. Kaschel

Institut für Halbleitertechnik,
D-70569 Stuttgart

kasper@iht.uni-stuttgart.de

Silicon germanium (SiGe) heterostructures on Si substrates are now routinely used in microelectronics manufacturing for BICMOS (Heterobipolartransistor HBT) and for CMOS (as stressors or stress transfer structures for strained MOS channels). Pseudomorphic growth below a critical thickness allows fabrication of high quality strained material comparable to silicon itself. The requirement of pseudomorphic growth restricts, however, the thickness and Ge content of layers to rather low values although the exact value of the critical thickness depends on several parameters like equilibrium, metastability, capping layers, etc.

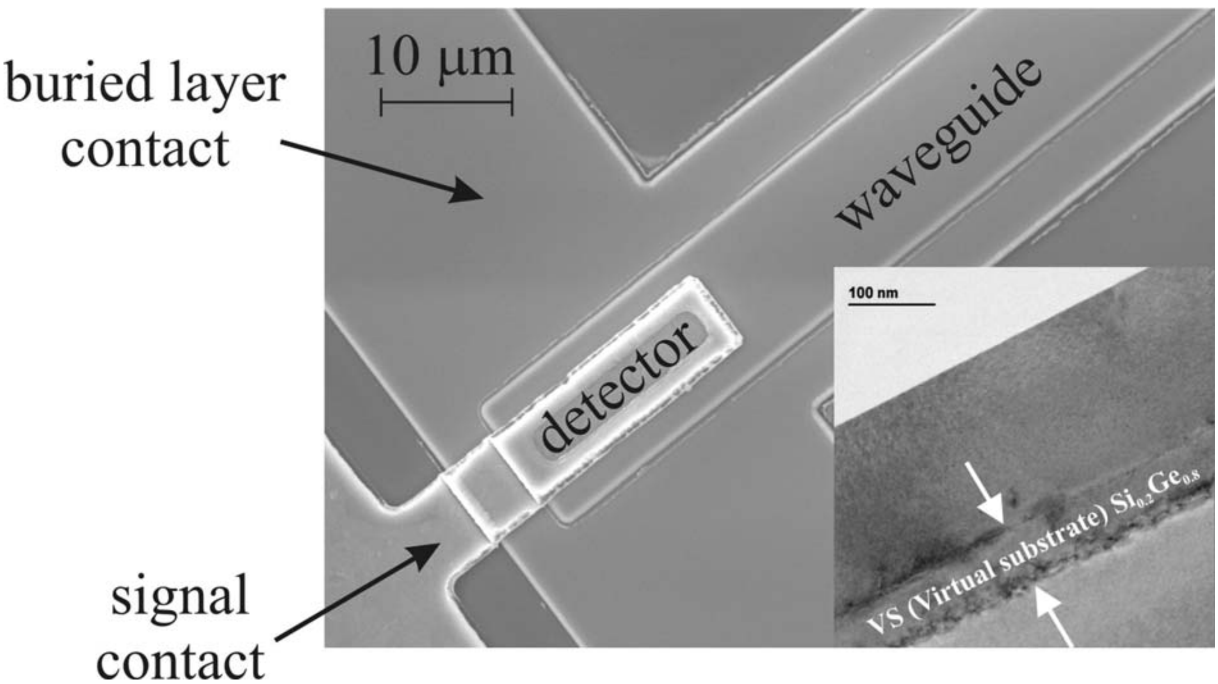

Fig. 1: Strain adjustment of device structures by an ultrathin (50 nm) relaxed SiGe buffer with high Ge content (80 %)

The need for higher Ge contents is fuelled by technology and device physics reasons. With Ge content the band gap, the band ordering, the strain and the mobility can be varied. High values of the band offset, high strain values and strain adjustment of compressive and tensile strains, several times higher hole mobilities than for any of the other familiar semiconductors, higher electron mobilities than for Si, improved optical absorption, extension of the wavelength into the near infrared, direct band-band transitions slightly above the indirect one and low temperature budget processing and activation of dopants are essential advantages. Challenges are the buffer layer needed for strain adjustment, the lattice perfection issues connected with dislocation networks, the chemistry of surface cleaning and oxide interfaces and integration concepts with standard IC's.

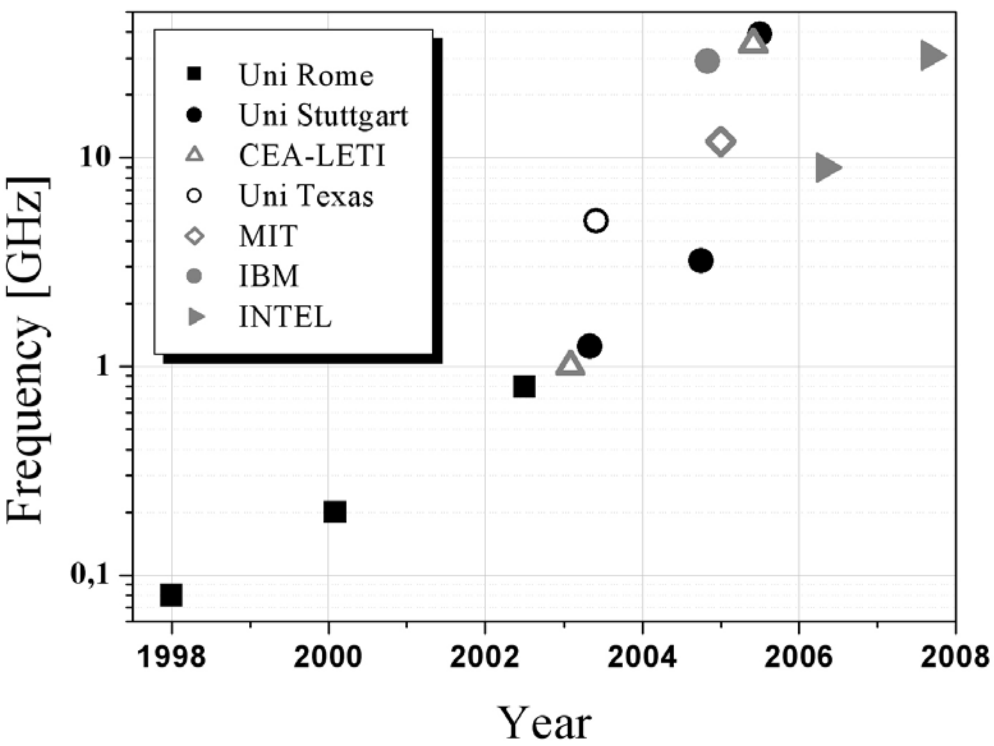

Fig. 2: Speed evolvement of Ge/Si based infrared photodetectors

The course treats the topics

- Basics of lattices mismatch and strain energy
- Energy gap and band offsets: Influence of strain
- Concept of critical thickness: equilibrium and metastability
- Dislocation networks: Nucleation and movement of dislocation. Strain relaxation (Fig. 1)
- Strain adjustment methods. Compliant and virtual substrate concepts. Global or local adjustment
- Field effect transistors: Technology, dual channels, S/D doping, Schottky S/D, Ohmic contacts
- Optical applications: Telecommunication, On-chip interconnects, imaging (Fig. 2)
- Germanium on insulator substrates (GOI)
- Future directions

The course provides a rigorous understanding of the basics and an overview of recent research topics. Time is allocated for discussions and proposals of participants. Please contact Erich Kasper if you want to summarize suggestions / results as poster within the course.