Characterization of $Si/Si_{1-x-y}Ge_xC_y$ Heterostructures for Device Applications

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With the commercial introduction of the Si/SiGe heterobipolar transistor (HBT) into main-stream integration technologies, process compatibilities become an important issue. A basic problem is, for example, the transient enhanced diffusion (TED) of boron out of the SiGe base layer upon thermal activation of the poly-emitter implant. As a remedy, the use of a carbon co-doped base has been proposed, in which a carbon concentration of a few tenths of an atomic percent have been shown to very efficiently suppress TED. On the other hand, great effort has been dedicated in the past to reduce the carbon concentrations in Si ingots as far as possible, because of the propensity of C to form complexes and β-SiC precipitates. In contrast to substitutional C, some of these complexes are known to introduce electrically active states in the band gap. It is therefore important to characterize the microscopic configuration in which C is present after processing of SiGe:C HBTs.

We addressed this problem by a combination of Fourier Transform IR spectroscopy (FTIR), x-ray diffraction, and SIMS studies on MBE-grown HBT structures with implanted poly-Si emitter. With the FTIR technique we are sensitive to substitutional/interstitial C and different forms of C-C configurations. By proper calibration of the active and reference sample thicknesses we achieve very high sensitivities regarding substitutional C, β-SiC precipitates and some carbon complexes. From this, together with the chemical information we get from SIMS, we find that both complexes, C-C and SiC precipitates play a role in the process.