ESRF	**Experiment title:** *High resolution x-ray diffraction study of boron doped Si/SiGe/Si and Si/SiGeC/Si HBT structures*	**Experiment number:** HS-576
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Report:

The experiments were divided into two parts: (i) the characterization of heterobipolar transistor (HBT) structures with boron doped SiGe and SiGeC base, and (ii) the investigation of SiGe(C)/Si(C) superlattice structures after annealing at different temperatures and pressure.

(i) HBT characterization

In former experiments (HS-268) we have found that the depth profile of Ge in SiGe(C) HBT structures prepared by differential epitaxy on Si substrates differs significantly between real device structures (e.g. transistor arrays of ring oscillators) and relatively large (4x8 mm^2) test structures used for conventional laboratory measurements. Now, we measured the 400 rocking curve with λ=1.05Å and 0.2x0.4 mm^2 beamsize in a 0.5x0.5 mm^2 area, which is usually foreseen for SIMS measurements in our test fields, on all chips of fully prepared 4"-wafers with different boron doping of the HBT base. This area was found to be small enough to be representative for real single transistor structures. Via rocking curve simulation the main parameters of the Ge depth profile (thickness of Si cap-layer, total thickness of SiGe(C) layer, plateau width and maximum Ge content) were obtained, and the mapping over the whole wafer area allows important conclusions about the homogeneity of the epitaxial growth process. Fig. 1 shows the results over the diameter of a relatively bad example.

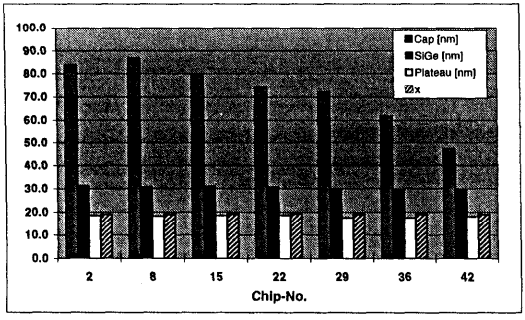
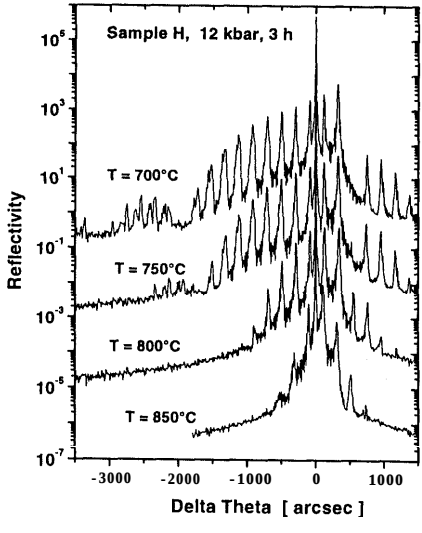


Fig. 1:

Characteristic parameters of a SiGe HBT structure (Si **Cap** layer thickness, **SiGe** layer thickness, thickness of the **plateau** region, and maximum Ge content x) measured in different chips across the 4" Si wafer.

(ii) SiGe(C)/Si(C) superlattice structures

The rocking curves of a set of 44 samples with SiGe(C)/Si(C) superlattice structures were measured with the same experimental conditions as mentioned above. The aim of these investigations was to study the influence of substitutional carbon on the Si/Ge interdiffusion in dependence on the C concentration and its position in the superlattice. Five different kinds of samples (SiGe/Si, SiGeC/Si, SiGe/SiC, SiGeC/SiC, and SiC/Si) with 20% Ge and O.l%, 0.2%, and 0.5% carbon were annealed at 700,750, 800, and 850°C under hydrostatic pressure of 12 kbar. Previously, similar sets of samples were studied after annealing under atmospheric pressure and a hydrostatic pressure of 6 kbar. The detailed structure and the strain distribution of the superlattice can be obtained by simulation of the rocking curves, which allows the determination of the diffusion coefficient. Fig. 2 shows as an example the rocking curves for a sample with $Si_{0.795}Ge_{0.2}C_{0.005}/Si_{0.995}C_{0.005}$ after annealing. The reduced number of diffraction orders of the superlattice with increasing annealing temperature is related to a smearing out of the Ge concentration due to diffusion.



For six selected samples a reciprocal space mapping of the diffracted intensities was carried out to separate the dynamical and diffuse scattering and following to determine the structural perfection of the annealed samples. It was found that diffuse scattering is only of minor importance, which shows that the structural perfection of the superlattice structures is preserved due to the influence of the carbon.

Fig.2:

Rocking curves of a $Si_{0.795}Ge_{0.2}C_{0.005}/Si_{0.995}C_{0.005}$ superlattice structure after annealing at 700, 750, 800, and 850°C under hydrostatic pressure of 12 kbar. The curves are shifted by two orders of magnitude relative to each other.