ESRF	**Experiment title:** Interface roughness in Si-based heterostructures	**Experiment number:** HS-114
Beamline: D5 (BL10)	**Date of experiment:** from: 19.9. to: 24.9.1996	**Date of report:** Oct. 16th, 1996
Shifts: 15	**Local contact(s):** Dr. Alexej Souvorov, Dr. A. Freund	***Received at ESRF:*** 09 DEC 1996

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Report:

We have investigated strain symmetrized SiGe/SiC superlattices grown by molecular beam epitaxy with and without Sb-surfactant using x-ray reflectivity. We have recorded the specular reflectivity, w-scans, 2θ-scans and offset ω-2θ-scans in order to evaluate the interface roughness in the multilayers and its correlation both parallel and perpendicular to the growth direction. The results are the following : the sample grown with surfactant showed distinct signatures of correlated interface roughness, whereas the sample without surfactant did not (see Fig. 1). A wavelength close to the absorption edge of Ge was used.

Additionally, we have investigated Si/Ge superlattices where the thickness of the Ge-layers was beyond the critical thickness for island formation. Thus, a high density of self-organized quantum dots which relieve part of the misfit strain has emerged during growth. We have studied the vertical and lateral arrangements of the island in these multiple quantum dot superlattices using x-ray reflectivity and x-ray diffraction. The diffraction patterns consist of sharp coherent contributions from the remaining two-dimensional part of the structure and broader diffuse contributions from the dots and the elastic deformation around them. We tried to assess the lattice constant of these coherently strained islands, which is different from the substrate lattice constant due to the mentioned partial elastic relaxation. Simulations of the measured curves, which are in progress, will allow to extract parameters like the lateral and vertical correlation lengths and the average lattice constant in the dots. We have acquired q_z- and q_x-scans as well as offset q_z-scans, which revealed a shift of the diffuse superlattice peaks with respect to the coherent ones in q_z-direction.

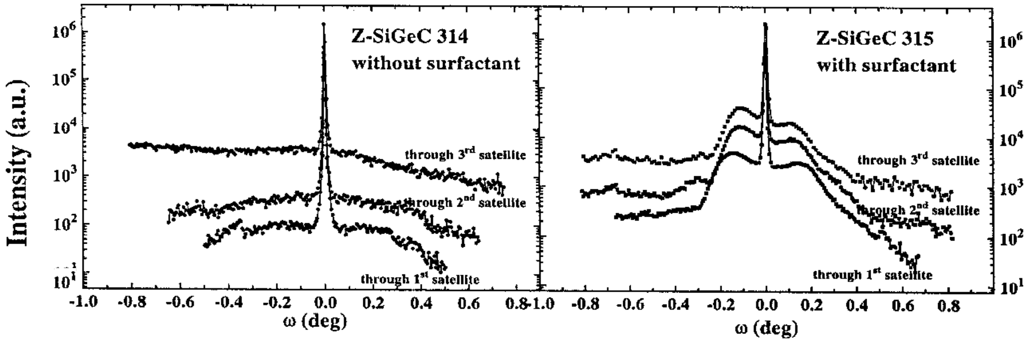

Fig. 1: ω-scans through the lst, 2nd and 3rd superlattice satellite for the sample with and without Sb-surfactant. (curves shifted along the ordinate)

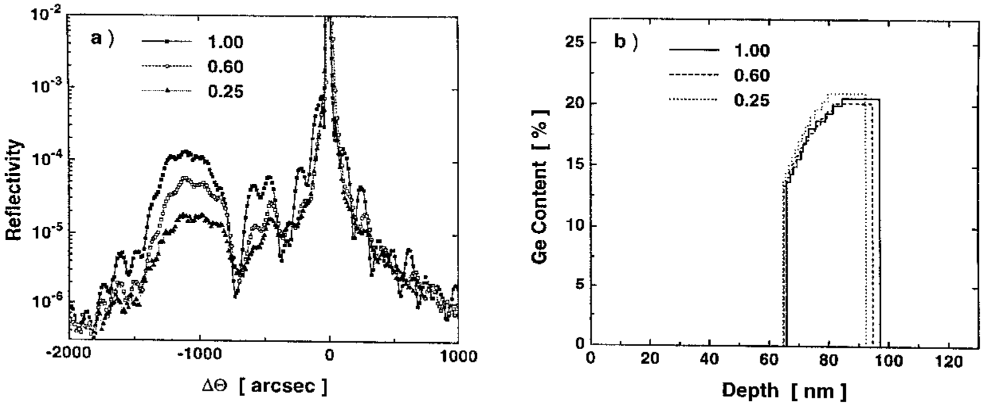

Fig. 2: (a) 400 diffraction curves (λ = 1.05 Å) of SiGe HBT structures with different degree of coverage with single crystalline SiGe; (b) depth profiles of Ge content obtained by simulation of the diffraction curves shown in (a).

Furthermore, we investigated the depth profile of the Ge content in SiGe-based heterobipolar transitor (HBT) structures prepared by differential epitaxy on Si substrates in its dependence on the lateral size of the areas (degree of coverage) with single crystalline SiGe layers. Fig.2a shows diffraction curves measured in areas with three different degrees of coverage (1, 0.6, and 0.25). Related to the illuminated area of crystalline SiGe, the layer signal at about 1100 arcsec and the amplitude of the oscillations of reflectivity due to the Si cap layer decrease. A simulation of these curves gives the depth profiles of Ge content shown in fig.2b with a characteristic gradient towards the Si cap layer. While the thickness of this cap layer is independent of the structure size (coverage), the thickness of the SiGe layer decreases with decreasing structure size. This behavior can be explained by different thermal conditions during the chemical vapor deposition process of epitaxy. This result is very important to correct the data obtained by x-ray monitoring techniques that use a large SiGe covered area on a wafer.