Applying the K-mapping technique to determine the spatial lattice tilt, strain and composition distribution in SiGe buffer layers

M. H. Zoellner[1], G. Chahine[2], M.-I. Richard[2,3], P. Zaumseil[1], P. Storck[4], T. U. Schülli[2] and T. Schroeder[1]

[1] IHP, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany
E-mail: zoellner@ihp-microelectronics.com
[2] European Synchrotron Radiation Facility, BP 220, F-38043 Grenoble Cedex, France
[3]Aix-Marseille Université, CNRS, IM2NP UMR 7334, 13397 Marseille Cedex 20, France
[4] Siltronic AG, Hans-Seidel-Platz 4, 81737 München, Germany

SiGe „virtual substrates“ are a promising approach for the integration of Ge and III/V semiconductor materials as closed films on a Si(001) platform. Such alternative semiconductor films are of great interest in advanced CMOS technology as high mobility channels and in high-efficiency solar cells with multi-junction semiconductor stackings. Compositional grading of $Si_{1-x}Ge_x$ strain relaxed buffer (SRB) layer enables to reduce the defect density for high performance by successively lowering the lattice mismatch of the heterostructure. For further improvements, several techniques were developed, e.g. back side stressor deposition, annealing and polishing steps. Although, growth and relaxation processes are well investigated since more than 20 years, it was not yet possible to monitor structural inhomogeneities (lattice tilt, micro strain, composition) by advanced X-ray microscopy.

In a previous study, we demonstrated by X-ray diffraction (XRD) and micro-focussed Raman mappings that the relaxation is driven by accumulated misfit stress during the growth and that the morphology variation of the cross-hatch pattern is correlated with the strain field but not with the Ge concentration fluctuation.[1] Here, we present the micro-focused X-ray diffraction mapping technique recently developed at the beamline ID01 of the European Synchrotron Radiation Facility (ESRF). This method was applied to $Si_{0.3}Ge_{0.7}$ graded buffers on 300 mm Si(001) wafers for the first time, giving local information on the (001) lattice plane tilt by analyzing the (004) Bragg reflection. The main objective was to investigate the influence of the chemo-mechanical planarization (CMP) by comparing an unpolished with a polished sample.

It was found that the spatial variation of the lattice tilt reflects the cross-hatch pattern. In general, the tilt variation appears broader on the unpolished sample. The double average tilt of the unpolished and polished sample are in the range of the full width at half maximum derived from laboratory based XRD rocking curve measurements, corroborating the reliability of this technique. Furthermore, both methods agree that the unpolished sample exhibits higher average tilt values. This is also confirmed by the statistic of certain regions of interest representing slightly tilted areas and highly tilted lines.

Moreover, it was tried to distinguish between spatial strain and composition variation by correlating the (004) with the (113) Bragg reflection and to find correlations with the surface morphology by additional atomic force microscopy (AFM) measurements. Further insights will be discussed in the presentation.

References

[1] - G. Kozlowski, O. Fursenko, P. Zaumseil, T. Schroeder, M. Vorderwestner, and P. Storck, *ECS Transactions* **50**(7), (2012) 613.