ESRF	**Experiment title:** Investigation of crystalline defects in 4H SiC single crystals and epitaxial layers	**Experiment number:** HC 544
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Report: *Motivation:* The main problem faced by the commercial applications of SiC is the quality of the substrates. The substrates are usually grown by sublimation methods causing inherent structural defects. In the seeded sublimation growth the seed crystal attachment, the seed type, reloading and continued growth, the growth front shape and spiral growth mechanism have crucial effect on defect formation and appearance. The final quality of SiC epilayers is expected to be to some extent influenced by substrate defects and surface preparation before epitaxy. Structural properties, such as bending and interface quality, of epitaxial layers grown by Chemical Vapor Deposition (CVD) need to be studied.

Experiments: The substrate and epilayer crystalline defects were imaged by white beam synchrotron X-ray projection and section topography as well as grazing incidence reflection topography. We investigated material grown at Linkoping University, together with commercial Cree wafers which were used for epi-substrates.

Results: The effect of stresses caused by rigid seed crystal attachment was studied. The bending of lattice planes was observed in the section topographs. Bending can lead to a formation of grain boundaries and macro-defects which were revealed in reflection topographs taken from samples cut perpendicular to the growth direction. In addition,

nonuniformities in the seed attachment cause uneven growth. In projection topographs defects corresponding to depressions at the surface could be observed. The growth face can also have different orientations due to different growth mechanisms, like facet and terrace growth. The face orientation affects the doping homogeneity. In the topographs darker and lighter areas due to different amount of defects were seen corresponding to facet and terrace growth, respectively. Domain boundaries with dislocations were found to coincide with growth facets boundaries. The interfaces between different growth runs were expected to be sources of macro-defects. Section topographs showed images of voids and micropipes at the interface as well as strong contrast indicating strain.

Comparison of growth on different seeds revealed that the crystals grown on off-axis seeds have a decreased misorientation and smaller micropipe sizes. Some bending like effect was observed due to polygonisation. As a comparison, 6H crystals were studied as well. It was found out that micropipes were larger and domain misorientation greater in the crystals. The regions between micropipes seemed to have less defects than in the 4H material.

In commercial 4H-SiC wafers domain boundaries containing a high density of edge dislocations with Burgers vector mainly in $<11\bar{2}0>$ direction were found. These domain walls were observed to increase towards the edge of the wafer. The structure was related to polygonisation and stresses in the crystal. Basal plane dislocation were frequently observed with either $<11\bar{2}0>$ (0001) or $<\bar{1}010>$ (0001) slip system. Also, straight lines originating from stacking faults were found in the substrate.

In section topographs taken from thick ($>60\mu m$) epilayers grown on off-axis (3.5" towards $<11\bar{2}0>$) 4H-SiC material, defects were imaged as dot-like features resulting from dislocation line, or zig-zag shaped lines originating from the epi-substrate interface. The dislocations had a Burgers vector component parallel to $<10\bar{1}0>$ corresponding to one part of partial dislocation. Dislocation densities were in some areas decreased in the epilayer as compared with the underlying substrate. The epi-substrate interface could be observed as a strong contrast line. The interface contrast was not continuous, thus features may be associated to localized defects, probably related to polishing damages.

These studies clarified the defects relate to both growth of SiC crystals and substrate preparations, thus providing a valuable knowledge in addressing the technological processes. The results of the experiments were presented at the 1st European Conference on Silicon Carbide and Related Materials at Crete, Greece, October 6-9, 1996. The articles, M.Tuominen et al. "Growth related structural defects in seeded sublimation grown Sic" and A.Ellison et al. "Wafer warpage, crystal bending and interface properties of 4H-SiC epi-wafers", will be published in the Journal DIAMOND and RELATED MATERIALS.