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Names and affiliations of applicants (* indicates experimentalists):

Marko Tuominen, IFM, Linköping University, Sweden
Alexandre Ellison, IFM, Linköping University, Sweden
Turkka Tuomi, Optoelectronics Laboratory, Helsinki University of Technology, Finland
Silvia Milita, E.S.R.F

Report: *Motivation:* The problem in using SiC high performance devices lies in the quality of the substrates. The substrates contains holes, so called micropipes (typically ϕ 0.1-3 μm) which are detrimental for the devices. Micropipes play an important role in the formation of domains with high density dislocation boundaries. An improper start of the crystal growth process can create several micropipes propagating into the crystal. Also specific growth parameters and their stability affect micropipe distribution and their density. The quality of SiC grown by seeded sublimation is expected to be to some extent influenced by seed defects and surface preparation before growth. Structural imperfections, bending and interface quality need to be studied.

Experiments: The substrate and epilayer were studied by white beam synchrotron X-ray projection and section topography. We investigated material grown at Linköping University, together with commercial available Lely platelets and epilayers grown on them.

Results: Epilayers were grown on off-axis modified-Lely wafers by sublimation epitaxy technique [l]. For some of the samples thermal etching was performed prior to the growth run. On the surface of these samples one could identify some additional defects and micropipes compared to samples grown without this etching. The topography measurements confirmed that there were defects at the interface which caused defects in the grown layer. In addition to the layered structure, clear misorientation between domains were observed in the section topographs. The recorded Laue pattern was deformed indicating a large strain in the lattice. In the large area topographs a clear dislocation network was revealed not normally seen in the material. Growth with a higher growth rate (lower inert gas pressure), 200 μm/h instead of 50 pm/h, seemed to result in better quality material.

Growth without the thermal etching step seemed to result in better quality material as well. Section topographs showed diminished misorientation and no interface between the epilayer and the substrate were observed indicating a non-strained interface. Probably the etching affects the formation of the steps in the beginning of the growth and larger steps may be formed causing enhanced defect formation and coalescence of defects at certain points leading to severe misorientation in the material.

As a comparison 100 μm 4H layers grown on 6H Lely platelets were studied. The samples appeared to be extremely strained having a strong curvature. Probably the dislocation centers, the step sources defining the 4H polytype causes stresses together with the fact that the substrate and the layer have different lattice constants which bends the crystal. The bending was so strong that the Laue pattern were heavily deformed and that multiple diffraction occurred in the sample.

A large number of 6H Lely platelets differing in crystal quality were studied in order to find out the defect occurrence prior to growth [2]. The information will be used as a selection criteria and for comparison purpose with the material later grown on them. The platelets were categorized into two groups. The crystals in the first group contained a highly distorted region, sometimes samples with a Frank-Read dislocation source were found. The observed dislocations had Burgers vectors parallel to the $[2\bar{1}\bar{1}0]$, $[\bar{1}2\bar{1}0]$ and $[\bar{1}\bar{1}20]$ directions. Otherwise the sample quality was good. The samples of the second group had much higher dislocation densities and they exhibited clear domain structure with misorientation resembling the domain structure in material grown by modified Lely method. The defects were gathered at boundaries between misoriented domains. The dislocation densities at the boundaries were high, up to 10^4 cm^{-2}. The bending of the lattice planes and thus misorientation were more pronounced along the edge attached to the growth cavity wall.

The best quality sample that was studied, did not show any dislocations in the synchrotron topographs. At the point where the growth started some dislocation contrast existed. After etching a few etch pits caused by screw dislocations were revealed. The etch pit density was extremely low, only 100 cm^{-2} over an area of 80 mm^2. Etch pits were gathered at boundaries between the areas grown in c 1 $\bar{1}$00 > directions. These areas where slightly misoriented to each other perpendicularly to the boundary. The misorientation was along the edge which was attached to the growth wall. In some samples growth disturbances caused areas with higher defect density at the platelet edge. Post-growth defects related to the crystal cooling process were identified: stacking faults with fault vector $1/6[20\bar{2}1]$, and precipitates at the edges of the platelet.

In conclusion, the importance of the defects at the seed-grown crystal -interface in the material quality were revealed in this study. Also a large number of Lely platelets were studied in order to better understand defects propagation from the substrate to the grown layers.

References:

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[2] M. Tuominen, A. Ellison, T. Tuomi, R. Yakimova, S. Milita and E. Janzén, submitted to Journal of Crystal Growth.