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Report:

The beamtime was used as well for the installation of a new and special double crystal topographic camera and for the measurement of the velocities of misfit dislocations in SiGe-layers at elevated temperatures.

Camera:

The camera consists of a rigid frame with ist own collimator system, a sample holder and a own control computer. This setup is required because of the special collimator system with a curvable collimator crystal plate. The curvature can be used for the compensation of dispersion effects or of the effect of sample curvature. The whole curvature range between a minimal concave radius of about IO m up to a minimal convex radius of about 10 m is divided into more than 2000 steps. in order to allow for a definite setting at working points in the very steep flank of narrow rocking curves, the sample holder allows angular steps smaller than 0.01 seconds of arc. Because of these special requirements the whole motor driver electronics for collimator and sample holder drives is concentrated in a separate PC. The whole camera setup is movable on air cushions and is, therefore, easily exchangable with the standard equipment at ID19. The setup is property of our research unit but available to any user (requests via staff of ID19. especially Jurgen Härtwig or Jose Baruchel).

As shown e.g. by the experiment discussed below, the setup works properly. There are however (at least) two problems left: the software still has some ‘rough edges’ and there is only a very primitive manual compensation for torsion effects at the collimator.

Our experience has shown that the software problems are essentially some inconveniences, whereas the torsion problem has to be overcome for regular use. A collimator system which allows for the additional necessary degree of freedom has been build and is under testing in our lab. It will be installed with our next beamtime

Misfit dislocation velocity:

Double crystal topography in reflection geometry has proven especially effective for the investigation of the development of misfit dislocations in very thin layers [11. However, this requires a special heating device in view of the reflection angles used (here 2θ close to $90°$), the necessary high mechanical stability and the low load acceptable at above mentioned sample holder. The experiments suffered from the fact that the optimum energy range close to 1,5 Å was not yet available. Because of the required geometry radiation close to 0.77 Å and a high order reflection (448) was used. The narrow halfwidth of this reflection led to low intensities and a comparatively low spatial resolution of about 5µm.

In spite of the low reflection halfwidth of about 0.25 seconds of arc and the considerable sample curvature of about 50 m radius topographs could be taken, which covered typically one fourth of the sample area. This became possible because of a compensating curvature of the collimator crystal (as mentioned above). A still better effect could be reached if some parasitic torsion of the collimator crystal could be avoided. This will become possible soon (see above).

Our efforts concentrated on the measurement of misfit dislocation movement during temperature treatment. As fig. l demonstrates for the example of a 74 nm thick $Si_{0.75}Ge_{0.25}$ layer on silicon substrate, prolongations of misfit dislocations up to about 1 mm during 1 hour measuring time were observed. In the given example of a sample grown by rapid thermal chemical vapor deposition (RTCVD) dislocation growth starts at very few nucleation centers (at first only about IO/cm').

Fig.1: Topographs taken from a RTCVD grown sample at a time of 30 min and 75 min, resp., after heating up to 520" C. Surface orientation (001). reflection vector [448], wavelength 0.77 Å

With weaker contrast a second and shorter dislocation becomes visible in the right hand picture below the extended horizontal dislocation, indicating that successively new. probably weaker nucleation centers become active one after the other. The same process becomes visible with MBE grown samples, however at a far higher density of nucleations centers. This makes evaluation of dislocation velocities rather difficult. Our results seem to support, that dislocation velocities are not critically dependend on growth procedure also at our small layer thicknesses. Instead, the number of nucleation centers does depend on that. In view of the possible burgers vectors there should be only two different dislocation contrasts per line direction. This does not hold and indicates that relaxation takes places via dislocation bundles. This is confirmed by additional measurements with atomic force microscopy. We are now interested to investigate this further and to try to study the blocking of misfit dislocations by interaction at crossing points. This is essential in understanding the continuous onset of blocking during relaxation [2].

[I] S.J. Barnett et al. j. Phys. D: Appl Phys. 28 (1995) A17

[2] G. Fischer, thesis, Univ. Potsdam 1997