| ESRF | **Experiment title:** Elastic strain in highly perfect, axially structured nanowhiskers established from a monolithic SiGe superlattice by metal-assisted etching | **Experiment number**: SI-2142 |
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**Report:**

Experiment SI-2142 aimed to investigate SiGe-Si nano-whiskers obtained by using metal-assisted etching on multilayer substrates (stacks of alternating SiGe and Si layers). The resulting grids of whiskers reveal a very high uniformity, can be ordered perfectly and moreover exhibit very flat interfaces at the the SiGe-Si multilayers within each wire.
Figure 1 shows an example of rather high height to diameter ratio of etched whiskers. At these ratios (and especially above) the top of the whiskers tend to bend and at very high whiskers finally stick together which may be related to the strain within the structure.


***Fig.1: Scanning electron micros-copy image show-ing etched SiGe-Si Nanowhiskers.***

Grazing incidence diffraction (GID) is very sensitive to the strain distribution inside the nanoscopic objects as well as their shape and lateral positional ordering. We performed our measurements using an experimental setup with a crystal analyser to improve the angular resolution.

Figure 2 shows one example of the measured GID data. In this picture the *ring-like shape* of the diffuse diffraction is very prominent. This ring is connected to the diameter of the (in this case circular) anowhiskers.
The second order of this *size-oscillation* was also measureable (not shown).

The corresponding real space picture of the same nanowhisker sample can be seen in Fig.1. Other samples with variations of diameter, height, different layer stacking sequences and Ge contents has been measured. *Lateral positional correlation* peaks from regular ordered whiskers could be seen (not shown here). The *influence of strain* due to the SiGe layer composition (and intermediate Si layers) of the whiskers lead to diffuse intensities at lower $q_{radial}$ values (vertical axis of Figure 1) which can be seen partially in Fig. 2 as well.

Grazing incidence small angle scattering (GISAXS) maps has been taken to *separate the strain from the shape* information since GISAXS corresponds to the fourier transform of the object(s) and is not sensitive to the strain whereas GID measurements are sensitive to both.

Additionally we measured HRXRD, which revealed, e.g., *super-lattice oscillations* that are originating from the multilayers inside the whiskers.

From finite element method (FEM) calculations we obtained the deformation profile in a three-dimensional model of the grown nano whiskers and already support our interpretations of the strain relaxation in SiGe layers.

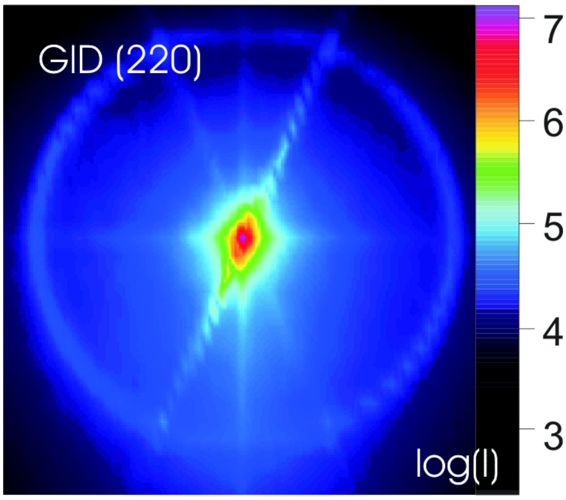


***Figure 2. GID(220) reflection of SiGe nanowhiskers (corresponding real space picture see Fig.1).***

<u>A publication is already in procress and is expected to be submitted whithin this half-year.</u>

Furthermore, the strain field data gained from the FEM calculations, mentioned above, can be used as input for scattering simulations. A comparison between these simulations and our experimental data will be used later on to confirm our interpretations concering the lateral positional ordering of the whiskers, vertical ordering (multi layers) as well as shape of the whiskers and strain.