ESRF	**Experiment title:** **Lateral Structural and Compositional Homogeneity of GeSn microdisks**	**Experiment number**: MA-2633
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Report:

The subject of this study was to spatially resolve the structural and compositional fluctuations within underetched GeSn microdisk resonators, as these parameters may have influence on the optical performance (optical losses and improve laser emission).

In particular, within the under-etched regions we expect enhanced strain relaxation made visible by the nano-XRD maps. Strain maps of partially under-etched microdisks will give insight in the relaxation mechanism in GeSn alloys, potentially coupled with GeSn stoichiometry inhomogeneities due to diffusion phenomena. Moreover, the elastic strain relaxation mechanism here is different from the typical “cartesian” bridge structures. Here the “radial geometry” may result in a distorted crystal structure with shear components. The possibility to determine the complete strain tensor will offer valuable feedback for theoretical calculation of the electronic band structure. In addition, XRD strain measurements on completely under-etched samples (GeSn disks on Si) allow to obtain an absolute reference for fully strain relaxed GeSn alloys which will serve as calibration for future Raman measurements.

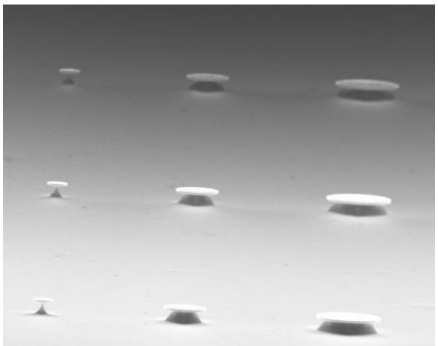

Fig.1: SEM image of GeSn microdisks of different diameter.

During the experiment X-ray energy was set to 8.9 keV. The X-ray focussing optics comprised a 300 µm Fresnel zone plate (FZP) with a 60 nm outermost zone size, a 60 µm beam stop (BS) and a 50 µm pinhole as order sorting aperture (OSA). Resulting, the focal distance and focal depth were 129.2 mm and 51 µm, respectively. The beam diameter was verified to be ~150 nm (perpendicular to ring plane) times ~200 nm (in the ring plane).

GeSn microdisks of different diameter and tin content have been investigated. Initially, the 008 reflection has been analyzed giving the local tilt orientation (vector) and value (color) with the corresponding statistic, exemplary shown in Fig. 2a and b for a 30 µm microdisk with nominal 13% Sn concentration. It is demonstrated that such large rings contain tilt components due to the lattice mismatch strain relaxation during growth (resulting in a cross-hatch pattern) and a component related to the elastic relaxation by under-etching forming a ring at the mesa edge.

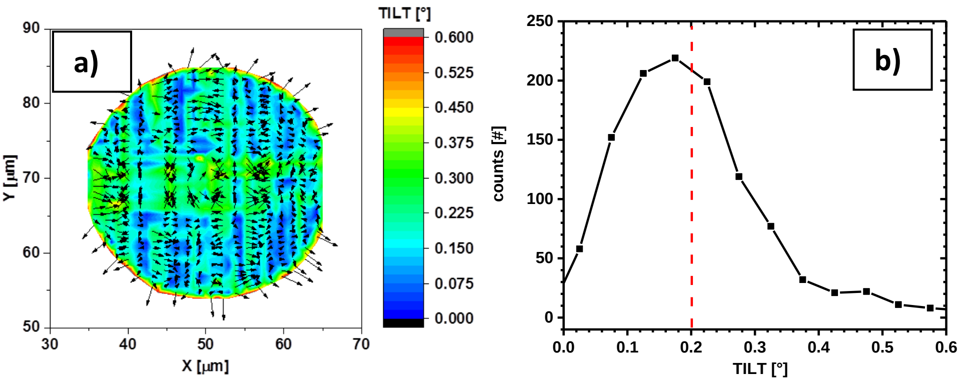

Fig.2: a) Tilt map and b) tilt histogram of 30 µm GeSn microdisk with 13% Sn.

As the chosen energy did not enable to measure the scheduled 113 reflection. Instead the accessible reflection 117 was measured. Unfortunately, this reflection is very sensitive to tilt deviation making the precise determination of strain and composition impossible by correlating the symmetric 008 and asymmetric 117 reflections. This is visualized in Fig. 3a and b showing histograms of scattering components q_x and q_y before and after tilt correction. This gives a much broader fluctuation of the in-plane lattice constant $a_{||}$ compared to the out-of-plane lattice constant $a_{\_|\_}$ (Fig. 3c).

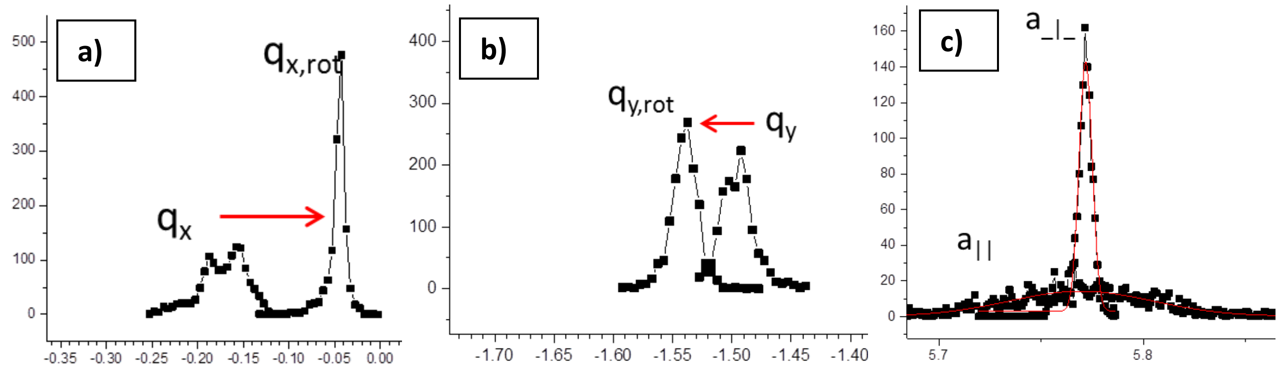

Fig.3: Historgams of a) q_x and b) q_y before and after tilt corrections and c) resultingin-plane and out-of-plane lattice constant.

Finally, an average concentration of 13.5 % and strain close to 0% is resulting which fits quite well. However, due to the wide scattering of $a_{||}$ the fluctuation demonstrated in Fig. 4 is unreasonable high and could not be confirmed by other techniques. For a precise determination other reflection with larger in-plane component, such as 335, is needed.

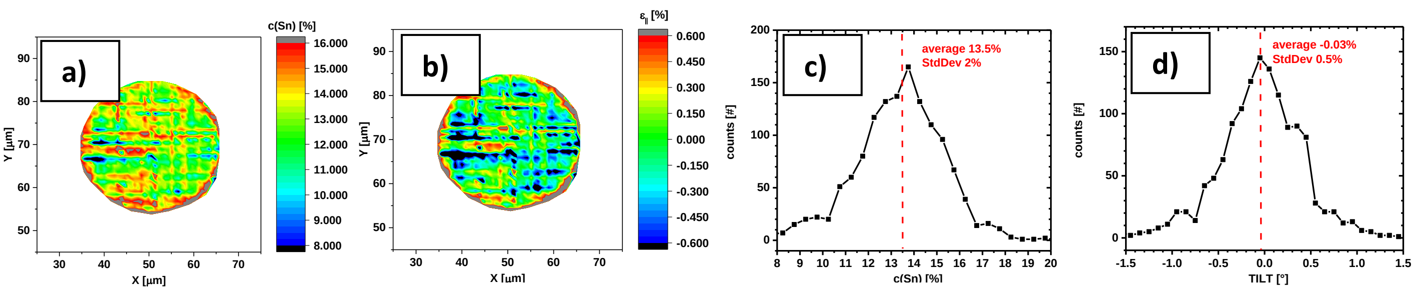

Fig.4: Mappings of a) Sn content and b) strain. Histograms of c) Sn content and d) strain.