In semiconductor nanowires, polytypic heterostructures provide a new class of heterostructures, where no material change occurs at the interface, but instead the crystal lattice type changes [1]. While in bulk materials only the ZB phase is stable, in III-V nanowires, polytypism between zincblende (ZB) and wurtzite (WZ) is introduced by stacking faults during growth. Recently methods have been developed to control the crystal type, and even change it reproducibly during growth [2]. WZ and ZB phases generally show different band gaps, and in several cases theory [3] and experimental data [4] hint on a type II band alignment. From samples with pure WZ and ZB, as well as 4H structure we were able to determine the lattice parameters of the different polytypes. Whereas bulk like lattice parameters were found for the ZB wires, the hexagonal polytypes show an increased c-lattice parameter, in comparison to the geometrically converted bulk values in InP, InAs and InSb [5, 6]. The inplane lattice parameter was found to be slightly decreased. The measured lattice parameters were found to agree with first principle calculations [7].

To study the mutual straining of segments of ZB and WZ, InAs NWs with alternating stacking sequence of ZB and WZ were grown by metal organic vapor phase epitaxy. Growth of such polytypic superlattices is so far only possible on InAs(111)B substrates and after growth of a WZ stem. This complicates the X-ray diffraction (XRD) investigations, since the signal of the ZB parts of the superlattices is covered by the substrate scattering. The signal from the WZ stem masks the scattering contributions from the WZ segments in the superlattice. The only possibility to obtain a signal solely from the superlattices is by measuring at the position of with respect to the substrate twinned ZB. Since after the WZ stem the relation of the ZB segment in the superlattice is not anymore fixed with respect to the substrate it is expected that half of the wires contain twinned ZB segments (denoted by TW) in the superlattice. Reciprocal space map measurements in the region of the (331) to (224)$_{\text{TW}}$ peaks were performed at beamline P08 at Hasylab for a series of samples with changed ratio of WZ and ZB. One of the reciprocal space map measurement as well as a corresponding scanning electron microscope (SEM) image are shown in Fig. 1. In the SEM image the WZ stem as well as the WZ/ZB superlattice region are visible.

Figure 1: Scanning electron microscope image of InAs nanowires with a polytypic superlattice (left). Reciprocal space map along the crystal truncation rod through the InAs (331) Bragg peak (right). Along the crystal truncation rod the wurtzite (101.5) and (101.6) Bragg spots as well as the twinned zincblende (224)$_{\text{TW}}$ peak are located.
The superlattice part is heavily tapered and overgrown. Furthermore a wire base with unknown lattice structure is clearly visible at every wire. The reciprocal space map measurement shows scattering from the InAs ZB substrate, the WZ parts of the nanowires as well as a contribution of twinned ZB. At the WZ Bragg diffraction peaks shape oscillations due to the nanowire diameter are observed along the \([\overline{1}1\overline{2}]\) direction, indicating the narrow size distribution of the nanowire stems. No superlattice satellites due to the polytypic superlattice structure could be found in any of the samples. Furthermore the position as well as width of the twinned ZB peak, which should be determined by the superlattice structure did not change throughout the sample series. Nominally at least a change of the peak width was expected, since the superlattices WZ to ZB ratio was changed by changing the length of the ZB segments. Due to the mutual straining of ZB and WZ segments the position of the peak should have been effected as well. The width of the twinned ZB peak along the \([\overline{1}1\overline{1}]\) direction was found to correspond to \(\sim 16\text{nm}\) to \(21\text{nm}\) in disagreement with the expected \(\sim 2\text{nm}\) to \(10\text{nm}\).

Destructive post-synchrotron experiments revealed that the twinned ZB signal must have been vastly determined by an source different than the superlattice. This conclusion was obtained by measuring the diffraction signal along the crystal truncation rod before and after removal of the wires by an ultrasonic bath. As can be seen in Fig. 2 the majority of the signal at the twinned ZB Bragg spot remained after the top parts of the wires with the superlattice were removed. We conclude that the TW-signal we measured stems from the wire foot or in general 2D layer growth on the substrate surface, where twinning was so far not observed and is not understood. Further growth studies are needed in order to optimize growth and enable a study of the mutual straining of WZ and ZB in polytypic superlattices.

References