In-situ studies of Strain in III-V nano wires in the early stages of growth

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In-situ monitoring of the crystal structure formation during self-assisted GaAs and InAs nanowire growth on patterned Si(111) substrates was performed in a combined molecular beam epitaxy (MBE) growth and X-ray characterization experiment. E-beam lithography patterned Si(111) substrates was used for selective area growth and reduced parasitic bulk growth in between the nanowires. This method enables us to characterize the relative formation rates of both Zinc-blende and Wurtzite structure during nanowire growth. Moreover, the effect of adding a small amount of Sb to the growth system was observed to have an immediately impact on the growth mechanisms, as it induced a solid phase transition from a Wurtzite to a Zinc-blende crystal structure.

Key word: Nanowires X-ray scattering, growth InAs, growth InSbAs

Introduction.

The crystal structure of self-assisted group III-V nanowires (NWs) usually exploits either the cubic zincblende (ZB) or hexagonal (WZ) crystal structure. In a recent experiment we have shown that the formation of WZ could be monitored *in-situ* using x-ray diffraction[i]. The resolution of this experiment was limited by a considerable amount of parasitic bulk structures in between the NWs. All these structures exploited the ZB crystal structure, and we were therefore limited to investigate the formation of WZ.

In this new experiment, we have used pre-patterned substrates for selective area growths, which considerably limit the amount of parasitic bulk structures[ii]. Si(111) are coated with a 30 nm SiO_2 layer and e-beam lithography used to fabricate 150 nm holes with a pitch of 2 μm.

Experiment:

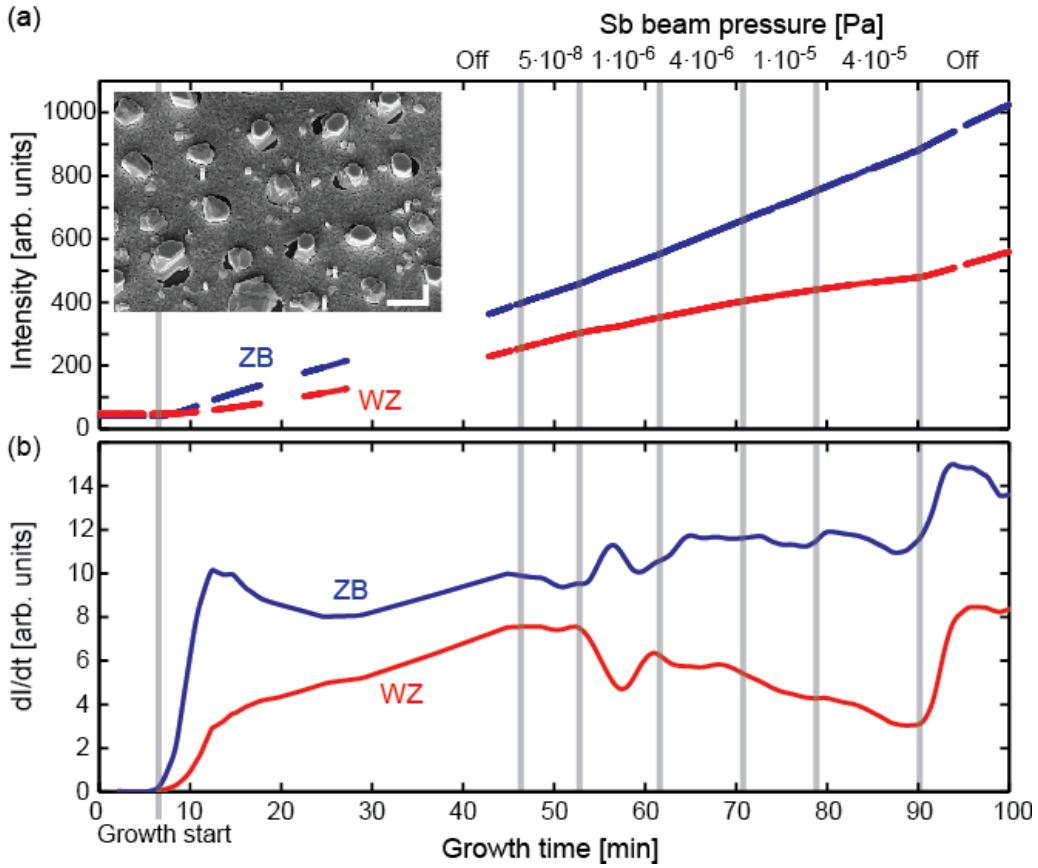
The experiments were performed on beamline BL11XU where a molecular beam epitaxy (MBE) chamber is attached to a surface X-ray diffractometer. The X-ray beam from the undulator source was monochromatized to photon energies of 20 keV with a beam size of 0.5 x 0.5 mm^2 on to the sample, and we therefore measure on a large ensemble of growing wires. The diffractometer is of the 4S+3D mode which is a combination of the 4S+2D diffractometer with an additional axis to azimuthally rotate the detector slit. The experiment was performed in the α=β mode where the angle of incidence is equal to the angle of exit.

Both InAs and GaAs NWs were grown on patterned substrates, and compounds using Sb, such as InSbAs, as well. The lattice mismatch between Si and GaAs is 4%, making the Bragg reflections easily distinguishable. For InAs the lattice mismatch is 11%, and for compounds with Sb even higer.

Result and Discussion:

For growth of self-assisted InAs NWs we saw an immediately effect of introducing Sb to the growth, as shown in the figure. Even a very little amount decreased the amount of WZ formation and increased the ZB formation. As we measure on the tail of ZB peak, the growth rates of ZB and WZ cannot be compared directly.

It has previously been reported that small



amounts of Sb influences the growth of Au-assisted InAs NW growth[iii], but the new study for self-assisted NWs shows that also the total growth rate is affected by the introduction of Sb.

Conclusion :

In conclusion, we have shown using an in-situ X-ray characterization setup that by using pre-patterned substrates it is possible to measure both the ZB and WZ crystal structure formation, and not only WZ as in previous experiments.This may lead to new insight into the mechanisms of III-V nanowire growth, and exciting future experiments may be proposed on the basis of this study. Moreover, the effect of adding a small amount of Sb to the growth system was observed to have an immediately impact on the growth mechanisms, as it induced a solid phase transition from a Wurtzite to a Zinc-blende crystal structure.

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