Self-Seeded Growth of InAs Nanowires: Fundamental Growth Study and Complex Structures

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Due to the possibility to epitaxially grow high quality heterostructures under a large lattice mismatch, semiconductor nanowires have received a lot of interest. Especially the combination of III-V compound semiconductors with Si is an attractive combination for applications. Most nanowire growth methods use Au particles to seed the one-dimensional growth. This poses a severe setback for electronic and optoelectronic applications, as Au is a deep-trap in Si, effectively making the Si useless for electrical applications. To overcome this problem, mechanisms for Au-free III-V nanowire growth have been developed, like self-seeded particle-assisted growth (SPAG) and selective area growth (SAG).

In this poster an overview over the outcome of our group over the last years of research on this topic are presented.

The results include extensive studies performed to deepen the understanding of InAs nanowire growth using a SiO_x mask layer. In the progress of this work it is shown that SPAG is the only possibility to describe the experimental findings [1].

Additionally, the temporal development of nanowire length and diameter are studied. Results obtained by growing 3 sample series, each evaluating the nanowire dimensions over growth time, are used as basis for a surface diffusion model describing nanowire growth. Interestingly, the only way to explain the obtained results is by assuming that only a single crystal layer at a time can grow at a wire mantle facet.

Using the knowledge of these fundamental studies, we tried to understand more complex and completely new systems:

First, we studied the position-controlled growth of InAs nanowires on Si substrates, which is achieved by a SiO_2 mask layer into which openings are etched. Using patterns with different opening dimensions, we can show that the nanowire dimensions for opening dimension ranging from 80 – 250 nm are independent of the opening size. In addition, much larger openings are tested as well, yielding the growth of crystallites instead of nanowires. This result is in agreement with the observations of the growth mechanism study and can be explained by a liquid In particle seeding nanowire growth.

In a second study the possibility to growth axial InAs/InAsP heterostructures is tested. As it is known that SPAG leads to nanowire growth, such heterostructures should be possible to achieve, if the particle can be preserved during the change of the group V precursor ratio. Here we will demonstrate the method used to obtain such a result, and how such a heterostructure typically looks like.

In a last project the principal possibility to grow another material with SPAG supported by a SiO_x layer is investigated. We can demonstrate that InSb wires can be grown in a self-seeded mechanism using the same type of sample preparation [2].

In conclusion, we demonstrated that self-seeded particle-assisted growth of nanowires is a versatile tool for nanowire growth. Still, many detailed aspects of this growth method remain to be investigated, offering exciting research opportunities.

References

[1] B. Mandl *et al.*, Nano Letters, 10 4443-4449 (2010)

[2] B. Mandl *et al.*, Nanotechnology, 22 145603 (2011)