Understanding the kinetics of III-V semiconductor nanowire growth using *in-situ* TEM

Carina B. Maliakkal,[1] Daniel Jacobsson,[2] Marcus Tornberg,[1] Axel R. Persson,[2] Jonas Johansson,[1] L. Reine Wallenberg,[2] Kimberly Thelander[1,2]

[1] *Solid State Physics, Lund University, Box 118, 22100 Lund, Sweden*

[2] *Centre for Analysis and Synthesis, Lund University, Box 124, 22100 Lund, Sweden*

Semiconductor nanowires have emerged as a highly promising technology for next-generation electronics and photonics, in particular due to their potential for forming novel metastable crystal phases, complex alloys and heterostructure combinations not achievable in bulk semiconductors. The most common method of fabricating these structures is the vapor-liquid-solid mechanism, which makes use of a catalytic liquid metal droplet. The development of these materials requires a fundamental understanding of how they form. Since nanowire growth is performed in a vapor phase atmosphere at high temperature, the dynamic processes controlling their formation cannot be directly deduced by analyzing only the final grown nanostructure. As such, the current mechanistic understanding of the synthesis process is insufficient for achieving the promised level of control.

In order to address this challenge, we use *in-situ* TEM imaging combined with *in-situ* compositional analysis to study the processes occurring at the interface between the metal droplet and nanowire, and how these control the final structure. Nanowires are grown in a Hitachi HF3300S aberration-corrected environmental TEM connected to a chemical vapor deposition system designed for III-V semiconductor growth. Growth is performed on a SiNx-based MEMS heating chip mounted on a holder with two separate microtubes for supplying the precursor gases. High resolution, high-frame-rate videos enable us to determine the rate at which individual semiconductor bilayers form, along with the interface morphology, catalyst geometry and nanowire crystal structure. The elemental composition of the catalyst is measured by energy dispersive X-ray spectroscopy as a function of the growth parameters. We identify different ‘regimes’ in which growth occurs that can be identified by the composition and structure of the catalyst, and in which different steps in the growth process control the overall formation rate as well as the structure of the material.

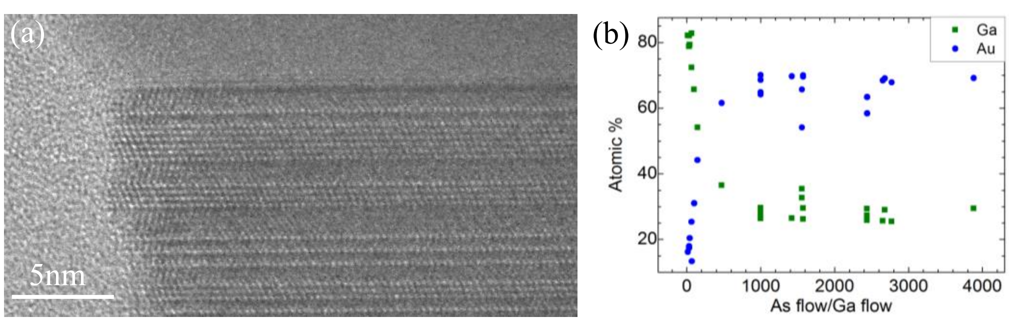

Figure 1 (a) Nanowire-catalyst interface (b) Catalyst composition at different Ga precursor flows

+ Author for correspondence: kimberly.thelander@ftf.lth.se