**Understanding Compound Nanowire Growth using In Situ Microscopy**

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**Abstract:**

Semiconductor nanowires are potentially useful in technology related to optoelectronics, electronics, sensors and qubits. A simplified mechanism of nanowire growth using a liquid metal catalyst is termed the vapor-liquid-solid (VLS) mechanism ⎯ whereby the reactants supplied in the vapor phase dissolves in the liquid metal catalyst, supersaturates and eventually precipitates layer-by-layer as a solid nanowire.1 Learning more elaborately the exact mechanism of the growth dynamics is required for engineering materials for future nanotechnology. In situ growth of nanostructures inside a transmission electron microscope (TEM) is a useful tool to understand the growth dynamics. Majority of the in situ TEM studies on nanowire growths were focused on elemental semiconductors – Si and Ge. However, compound semiconductor materials have several added advantages such as in light emission/absorption-based devices.

We investigated compound nanowire growth mechanism in an environmental TEM. We chose GaAs nanowires grown using Au catalyst as a model system. While the nanowires were growing at different conditions, we measured the particle composition using energy dispersive X-ray spectroscopy and found there is significant amount of Ga alloyed into the Au seed particle, but there is hardly any As in the catalyst.2

The reduced As availability also manifests in the layer-by-layer growth dynamics. Using in situ TEM growth of individual layers can be observed in real time and recorded as high-frame-rate videos. Growth dynamics in nanowires have two important parts – the nucleation of each layer at the catalyst-nanowire interface followed by lateral growth of the nucleus to a full bilayer. We define growth time for each bilayer as the ‘layer-completion time’ and the waiting time between successive layers as ‘incubation time’.3 Unlike assumed by most theoretical models, we observed that the layer completion is not instantaneous. Rather it is limited by the low As concentration in the catalyst. The layer completion and incubation times were investigated with two sets of experiments – an As-precursor series and a Ga-precursor series. We demonstrated independent control of nucleation and layer growth using precursor flow.

References:

1. Wagner, R. S. & Ellis, W. C. Applied Physics Letters 4, 89 (1964).

2. Maliakkal, C. B. et al. Nature Communications 10, 1 (2019).

3. Maliakkal, C. B. et al. ACS Nano 4, 3868 (2020).

**Biography of presenting author**

Dr. Carina B. Maliakkal obtained her MSc (Physics) from the University of Hyderabad, India and her PhD (Physics) from Tata Institute of Fundamental Research. Her PhD research was based on understanding the growth of III-V semiconductor nanowires. During her postdoctoral research she investigated compound nanowire growth using in situ transmission electron microscopy at Lund University. Her interests span across in situ TEM, crystal growth and nanowires.

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