Engineering InGaAs Nanowire Composition by Selective Area Metal Organic Vapour Phase Epitaxy

Z. Azimi[A], A.S. Ameruddin[A], H.H. Tan[A], C. Jagadish[A], J. Wong-Leung[A]

[A]Department of Electronic Materials Engineering, Research School of Physics and Engineering, The Australian National University, Canberra, ACT 2601, Australia

Ternary and quaternary alloys of III-Arsenide semiconductor nanowires (NWs) are attracting significant interest as building blocks of future optoelectronic devices [1]. Amongst other advantages they feature tunable bandgap energies by varying the alloy composition. Recently, InGaAs nanowires were synthesized by vapor-liquid-solid (VLS) growth using Au nanoparticle catalysts [2]. However, the targeted pure wurtzite (WZ) and zinc blende (ZB) crystal structures could only be achieved for few $In_xGa_{1-x}As$ compositions. Furthermore, an inhomogeneous content of In was observed along the nanowires [2].

Here, we report the growth of vertically uniform $In_xGa_{1-x}As$ compositions for a wide compositional range ($0<x<1$). The latter were achieved by optimizing selected area epitaxy (SAE) and metal organic chemical vapour deposition (MOCVD) growth conditions on GaAs substrates. Our transmission electron microscopy (TEM) results show that GaAs has a predominantly ZB structure whereas InAs nanowires have a WZ crystal structure. For the GaAs nanowires, we observe a change in the stacking fault density along the length of the nanowires. In particular, the base of the GaAs nanowires are heavily defective with increasingly thicker ZB twin segments (~ 150 nm thick) towards the top of the NW as can be seen in Figure 1.

We also observe that for a given nominal V/III ratio, the In/Ga composition within the nanowires is dependent on two factors: the growth temperature and the pitch size. We observe a higher Ga content in InGaAs nanowires with higher growth temperature and smaller pitch size. TEM analysis shows a trend from predominantly WZ phase for higher In content to predominantly ZB for higher Ga content. We believe these findings provide directions for the future engineering of InGaAs based devices.

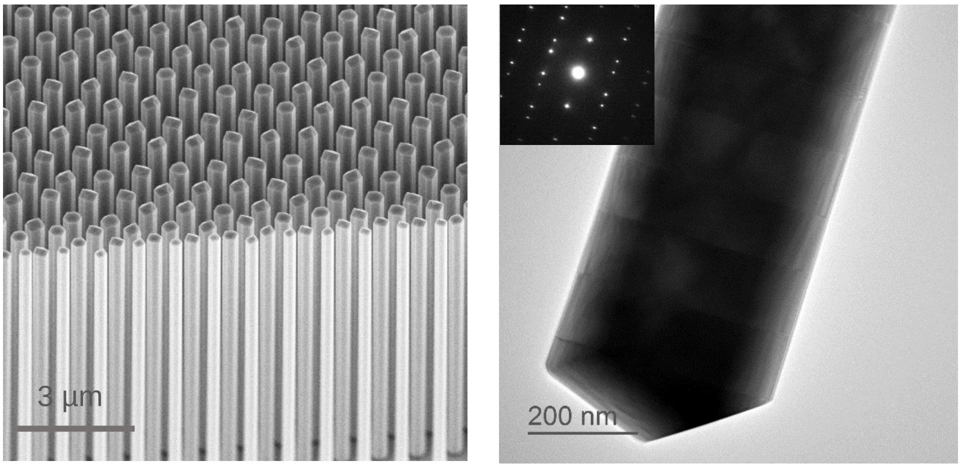

Figure 1. (a) Scanning electron microscopy image of GaAs NW, (b) TEM image at the top of the GaAs NW.

References

1. H. Kim et al, Nano Lett. 16 (2016), 1833−1839.

2 A. S. Ameruddin et al., Nanotechnology, 26, (2015) 205604.