Understanding the growth of $In_{0.85}Ga_{0.15}As$ core-shell structured nanowires

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Ternary III-V nanowires, although less studied than their binary counterparts, have attracted an increasing interest as they allow for the tunability of desired band-gap materials for different applications by modulating composition fraction of their alloys. Among them, InGaAs nanowires have demonstrated to be technologically important for a wide range of applications, attributed to their tunable band gap ranging from the near-infrared region to the infrared region, which makes them an ideal material system for numerous optoelectronic devices, such as light-emitting diodes and nanolasers. The intrinsically smaller band gap of In-rich InGaAs than Ga-rich InGaAs or GaAs would realize carrier confinement when it forms heterostructures with other III-V materials of larger band gap and its high electron mobility makes it possible for applications in high electron mobility transistors and high-efficiency photodetectors. Therefore, InGaAs nanowires with high In concentration are highly desirable.

In this study, we demonstrate the growth and compositional characteristics of Au-catalyzed InGaAs nanowires on GaAs $\{111\}_B$ substrates under a high In concentration using molecular beam epitaxy. Through detailed electron microscopy investigations on the grown InGaAs nanowires and their cross sections from different regions (refer to Figure 1), we found that InGaAs nanowires have the average In concentration of more than 80 at.% and they spontaneously formed In-rich cores and Ga-enriched shells. More interestingly, we found that, during nanowire growth, the compositional difference between the nanowire cores and shells decreases towards nanowire bottom regions and the Ga concentration in the nanowire cores decreases along the nanowire growth direction, which can be derived from the enhancing strain relaxation with increasing the shell thickness at the nanowire bottom and the limited Ga diffusion length along the nanowires. The fundamental reasons behind these new phenomena were investigated and the growth mechanism of our ternary InGaAs nanowires was proposed [1].

References

1. Zhou C, Zhang XT, Zheng K, Chen PP, Lu W, Zou J. *Nano Letters* **2017**, *17*, 7824.

Acknowledgements

This work was financially supported by the Australian Research Council. The Australian Microscopy & Microanalysis Research Facility is acknowledged for providing characterization facilities.

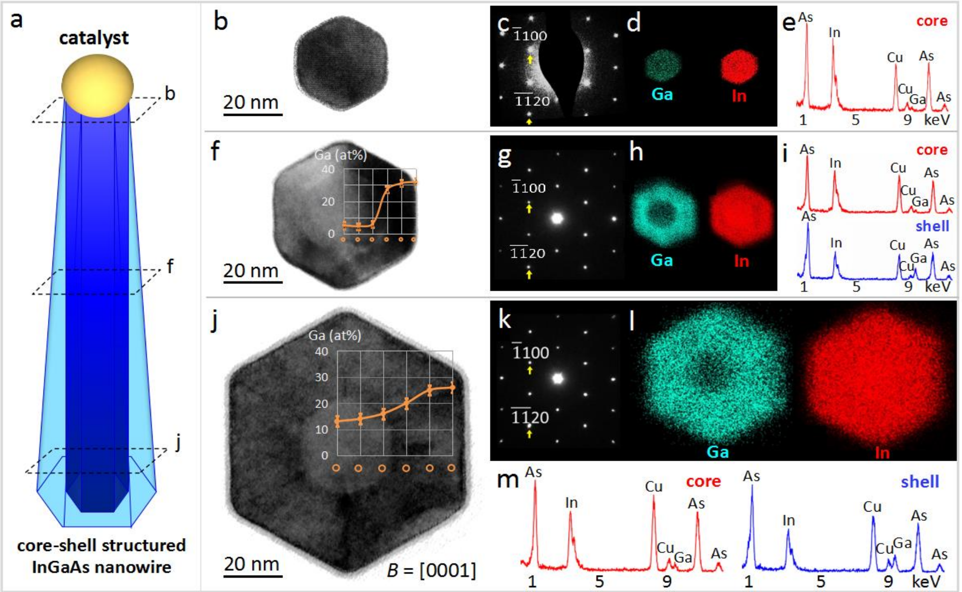

Fig. 1 (a) Schematic illustration of a typical InGaAs core-shell structured nanowire. (b,f,j) Bright-field TEM images of typical cross-sections from the InGaAs nanowire bottom, middle and top region, respectively. The insets in (f,j) are the plots of Ga concentrations at different positions of the cross-section as denoted in (a). (c,g,k) Corresponding SAED pattern viewed along the [0001] zone-axis. (d,h,l) EDS Ga and In maps of the cross-sections. (e,i,m) Typical point analyses of energy dispersive spectroscopy taken from different sections of nanowire core and the shell.