III-V nanostructures – from growth to devices

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Abstract: Group III-V semiconductors have revolutionised electronics and optoelectronics due to their superior physical and optoelectronic properties including high carrier mobility, direct bandgap and band structure engineering capability. Reducing the device size to nanoscale brings many unique properties, such as large surface-area-to-volume ratio, high aspect ratio, carriers and photons confinement effect. In particular nanowires, which have diameters of several to tens of nm's and µm's long, have very high aspect ratio, large surface-area-to-volume ratio and allow carrier/photon confinement in two dimensions, which lead to their unique properties. These nanowires are usually grown by the so-called vapour-liquid-solid mechanism, which relies on a metal nanoparticle to catalyse and seed the growth. An alternative technique to grow the nanowires is by selective area growth technique, where a dielectric mask is first patterned on the substrate prior to growth.

To date most efforts on the growth of group III-V nanostructures have been limited to nanowires. However, using selective area growth it is also possible to obtain other functional nanostructures beyond the limitation of rod-like nanostructure. By changing the pattern design on the mask and growth conditions, nanostructures of various shapes can be engineered such as membranes, flowers, rings, spirals, stars, ellipses etc. These shape-engineered nanostructures open up possibilities of new applications based on devices with novel geometries and metasurfaces.

This tutorial will give an overview of the epitaxial growth process to synthesise the nanostructures and their applications to various optoelectronic devices such as lasers, single photon emitters, photodetectors, sensors and solar cells.

Prof. Tan received his B.E. (Hons) in Electrical Engineering from the University of Melbourne in 1992 and PhD in Materials Engineering from the Australian National University in 1997. He has co-authored over 600 journal papers and 9 book chapters, with over 26,000 citations and a *h*-index of 78. He is also a co-inventor in 8 US and 2 Australian patents related to laser diodes, infrared photodetectors, photonic devices and catalysis. Prof. Tan is a Fellow of the IEEE "*for contributions to compound semiconductor optoelectronic materials and devices*". He was also the Distinguished Lecturer for IEEE Nanotechnology Council (2016 & 2017) and IEEE Photonics Society (2016-2017). He was named "*Australia's leading researcher in nanotechnology*" by The Australian's research magazine in 2020. Prof. Tan is the director of the $30M Australian National Fabrication Facility - ACT Node, which provides micro/nano-fabrication facilities for the R&D communities.