III-V Semiconductor Heterostructures grown by Selected Area Epitaxy Metal Organic Chemical Vapour Deposition

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III-V semiconductor nanowires are of interest for applications in optoelectronics, microelectronics and thermoelectric devices. At the department of Electronic Materials Engineering, the growth of semiconductor nanowires by metal organic chemical vapour deposition (MOCVD) is a core research activity. III-V nanowires adopt two crystal structures, zinc blende (ZB) and wurtzite (WZ) but have also been shown to have a combination of cubic and wurtzite phases. The crystal structure of the nanowires determines the bandgap of the semiconductor and mixed phase nanowires behave like a semiconductor heterostructure. III-V semiconductor nanowires typically grow along the <111> direction for ZB and <0001> for WZ. In this presentation, we will concentrate on recent results from nanowires grown by selected area epitaxy (SAE) MOCVD of (a) InGaAs nanowires and (b) InP/InGaAs quantum well heterostructures. SAE growth is initiated by first depositing a 30nm SiO_x layer on either GaAs or InP substrates to be used as a mask. Electron beam lithography was used to pattern these substrates with circular openings and the oxide layer removed in these circular hole openings using a buffered HF etch. The patterned substrates are ready for growth. (111)A InP wafers and (111)B GaAs wafers were used as substrates for InP/InGaAs and InGaAs nanowire growth respectively. Scanning electron microscopy was performed to assess the size of the openings prior to growth and the morphology of the nanowires after growth. Optimised nanowires were selected for detailed cathodoluminescence studies and transmission electron microscopy studies. Depending on the diameter of the nanowires, cross-sectional transmission electron microscopy (TEM) samples are prepared by focused ion beam (FIB) methods or alternatively some as-grown nanowires were placed onto a TEM grid using a glass needle and an optical microscope. TEM analysis of the nanowires was carried out to determine the crystal structures. Electron dispersive X-ray spectrometry (EDS) analyses were carried out to determine the composition and homogeneity of InGaAs nanowires along the nanowires. Aberration corrected scanning transmission electron microscopy on the quantum well structures reveals distinct differences in crystal structure between the quantum well (InGaAs) and InP barrier layers. The interface of InP grown on InGaAs appeared to be more diffused compared to InGaAs grown on InP. Both axial and radial heterostructures were carefully examined.

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