III-V NANOWIRES FOR VERTICAL DEVICES ON SILICON

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Integration of III-V semiconductors with silicon has been a longstanding goal, as it would offer an excellent opportunity for fuller exploitation of the attractive (opto)electronic (direct bandgap) and electronic (high mobility) properties of III-V semiconductors by means of the existing reliable and cost-effective silicon-based technology. Until now the mismatch in lattice constants and thermal expansion coefficients have hampered progress. Recently semiconductor nanowires have emerged as the most promising candidates to meet this challenge, since nanowires from various III-V materials (InP, GaAs, GaP and InAs) have been grown epitaxially on germanium[1] as well as on silicon[2] substrates using the vapour-liquid-solid (VLS) growth mechanism.

In this contribution I will report on the exploration of the potential of III-V semiconductor nanowires grown on silicon for the fabrication of electronic devices such as bipolar and field effect transistors. Critical for the device performance is the quality of the interface between the III-V nanowire and the silicon substrate. Therefore detailed structural characterization has been carried out by means of scanning electron microscopy (SEM) and transmission electron microscopy (TEM) in order to asses the epitaxial growth and the quality of the heterointerface.

In order to improve the transport and optical properties within the nanostructure more complex structures including segments of different III-V materials and core/shell structures have been investigated. Of particular interest is the realization of vertical devices as the first step towards the fabrication of arrays of nanowire devices. Results on three-terminal field effect devices with a wrap gate will be presented.

At very small wire diameter quantum effects become important: the nanowires become quasi-onedimensional and deviations from bulk semiconductor physics develop. A brief discussion of the relevant length scales will be given, and implications for optical and transport properties will be pointed out.

References:

[1] E.P.A.M. Bakkers et al., Nature Materials, Vol.3, 769, 2004

[2] T. Martensson et al., Nano Letters, Vol.4, No.10, 1987, 2004