Quantum nanostructures at atomic scale: From vertical hybrid nanowires to planar nanowire networks and 2DEG/2DHG systems

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Hybrid superconductor/semiconductor-based quantum devices (e.g.: for quantum computing applications) are mainly based on 3 different technologies: vapour-liquid-solid (VLS) grown vertical nanowires, selected area growth (SAG) nanowire networks and 2-dimensional electron gases (2DEG).

First of all, by using atomic-scale aberration corrected Scanning Transmission Electron Microscopy (AC STEM) and 3D modelling, we will study the influence of polarity on the development and properties of these complex NW-like hybrid heterostructures vertically grown by VLS. [1-3]

In a second part, we will show the natural evolution of this vertical technology to the flat growth of NW networks on III-V substrates. In these complex core@shell or confined multilayer nanostructure configurations, strain relaxation mechanisms during the epitaxial growth play a key role in determining their final morphology, crystal structure and physical properties. To analyse these mechanisms, in the present work, atomic-scale AC STEM studies are performed on horizontal arrays of nanowires. Core morphology-dependent strain fields, involving plane bending and the resulting formation of low angle polar boundaries, are observed. The origin of this phenomenon and its consequences on the electronic band structure are discussed. Monochromated Valence Electron Energy Loss Spectroscopy is employed to spatially map the heterostructure's bandgap with sub-nanometer resolution and certify the influence of the high mismatch induced strain on the topological electronic properties at the interface of the core-shell region. [4-7]

Finally, we will address the newly developed 2DEG heterostructures based on SiGe, fully compatible with CMOS technology, were the strain and composition at the Ge quantum wells will determine their final quantum properties. [8-10]

References

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Figures

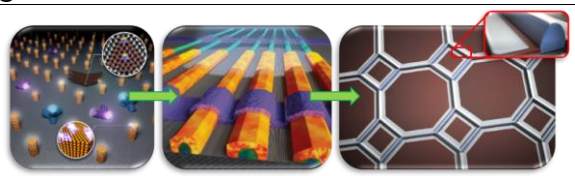

Figure 1: Semiconductor nanowires (r)evolution: from vapour liquid solid to guided growth and selected area growth.