The Nanowire (R)evolution viewed at atomic scale: from VLS vertical systems to planar quantum networks

Jordi Arbiol [a,b]
Sara Martí-Sánchez, Marc Botifoll
[a] *Catalan Institute of Nanoscience and Nanotechnology (ICN2), CSIC and BIST, Campus UAB, Bellaterra, 08193 Barcelona, Catalonia, Spain*
[b] *ICREA, Pg. Lluís Companys 23, 08010 Barcelona, Catalonia, Spain*
arbiol@icrea.cat

Abstract

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). By using 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.[1-6] In a second part, we will show the natural evolution of this vertical technology to the flat SAG 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 analyze these mechanisms, atomic-scale AC STEM studies are performed on horizontal arrays of nanowires. Monochromated Valence Electron Energy Loss Spectroscopy will be 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.[7-12] 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 [13].

References

[1] M. de la Mata, Nano Lett. 12 (2012) 2579
[2] M. de la Mata, Nano Lett. 14 (2014) 6614
[3] M. de la Mata, Nano Lett. 16 (2016) 825
[4] M. de la Mata, Nano Lett. 19 (2019) 3396
[5] M. Zamani, Adv. Mater. 32 (2020) 2001030
[6] M. Valentini, et al., Nature, 612 (2022)442
[7] E. Oksenberg, ACS Nano, 11 (2017) 6155
[8] F. Krizek, Phys. Rev. Mat., 2 (2018) 093401
[9] S. Vaitiekėnas, Phys. Rev. Lett. 121 (2018) 147701
[10] M. Friedl, Nano Lett., 18 (2018) 2666
[11] P. Aseev, Nano Lett., 19 (2019)218
[12] S. Martí-Sánchez, et al., Nature Commun., 13 (2022)4089
[13] D. Jirovec, et al., Nature Mat., 20 (2021)1106

Figures

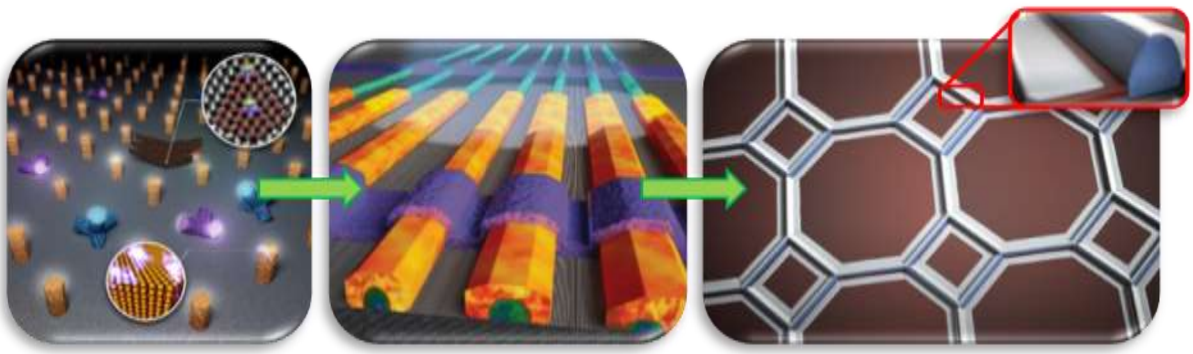

Figure 1: Semiconductor nanowires (r)evolution: from vapour liquid solid to guided growth and selected area growth.