III-V semiconductor nanowires: structural vs.electrostatic properties

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Quasi-one-dimensional systems such as semiconductor nanowires (NWs) are considered as one of the main possible building blocks for nanoscale electronic and optoelectronic devices. From the possible choices of materials, InP and InAs NWs have been extensively investigated due to their large carrier mobilities and small surface recombination rates. Recent works evaluating possible nanoelectronics devices, however, have shown that the electrostactic characteristics of these nano-objects still need to be addressed.

We discuss here the synthesis and spatially-resolved characterization of nanowires based on III-V compounds. In particular, we have studied the growth evolution of InP and InAs NWs obtained using catalytic Au nanoparticles (NP) and the vapor-liquid-solid mechanism. Our results suggest the existence of different 'incubation times' for NP supersaturation prior to InP and InAs NW growth. For InP/InAs/InP heterostructured NWs, InP/InAs interfaces were well defined. However, InAs-rich regions were formed close to the NW/NP interface during sample cool down, indicating a stable phase in the NP not predicted from bulk phase diagrams.

The electrostatic characteristics of the NWs were investigated with spatial resolution by Kelvin Probe Force Microscopy (KPFM). This technique can provide information on the charge distribution and electronic structure of nano-objects. KPFM images show a variation of surface potential (SP) along individual NW's and a dependence on NW diameter. For heterostructured NWs, changes in SP values reflect the different materials and the presence of the nanoparticle (NP) used to catalyze the growth. Our results suggest there is an effective 'electrical contact' formed at the NW tip due to the presence of the metallic NP as well as a depletion region associated to the increasing surface to volume ratio at the thinner regions of the NW.

Figures:

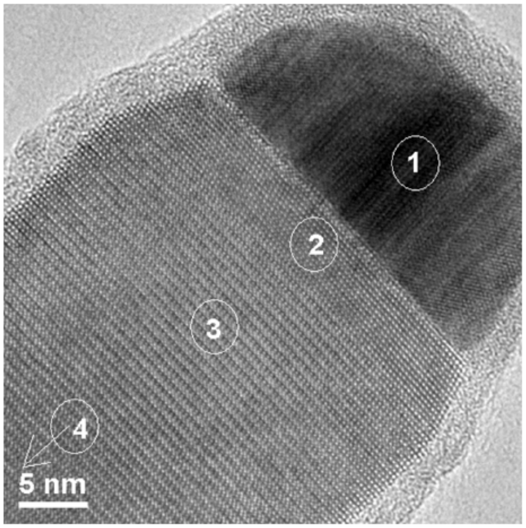

Fig.1 – High Resolution Transmission Electron Microscopy of the heterostructured InP/InAs/InP NW showing a wurtzite/zincblend structural transition. Energy Dispersive Spectroscopy measurements at the marked spots have shown the presence of up to 20% in As concentration near the NW/NP interface (neck region) while pure InP is at the NW body segment.

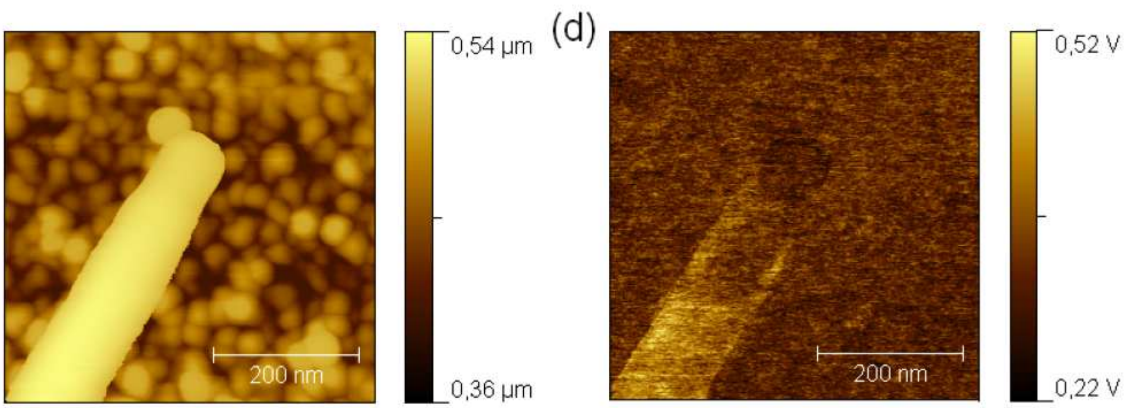

Fig.2 – Topography and Surface potential (SP) images of the heterostructured NW apex on top of a Pt film which acts as ground electrode.