KN06 | Crystal Phase Control In Nanostructures As A Platform For Atomic Scale Tailoring Of Electronic, Optical And Chemical Properties.

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The III-V nanowire (NW) technology platform has reached a level of advancement that allows atomic scale control of crystal structure and surface morphology as well as flexible device integration. In particular, controlled axial stacking of Wurtzite (Wz) and Zincblende (Zb) crystal phases is uniquely possible in the NWs. We explore how this can be used to locally control electronic, optical, and chemical properties with atomic scale precision opening up for 1D, 2D and 3D structures with designed functionality for novel electronic, photonic and quantum technologies. To do this, we use atomically resolved Scanning Tunnelling Microscopy/Spectroscopy (STM/S), femtosecond Photo Emission Electron Microscopy (PEEM) and X-ray diffraction imaging techniques to study both individual nanowires as well as specially designed functioning nanoscale devices.

We measure local density of states of Zb crystal segments in Wz down to single atomic scale crystal lattice change and find that the "bulk" electronic structure is preserved locally in even the smallest possible segments. We demonstrate a novel device platform allowing true observation of single atom changes across a III-V NW device simultaneously with full electrical operation. We explore the surface alloying of Sb and Bi into GaAs NWs with controlled axial stacking of Wz and Zb crystal phases demonstrating a simple processing-free route to compositional control of 1D an 2D materials at the monolayer level on the NWs. We investigate local hot electron dynamic response and control down to a few femtoseconds temporally and a few tens of nanometre spatially using the Wz and Zb crystal phases.