Resonant excitonic effects in the density of states of InP nanowires

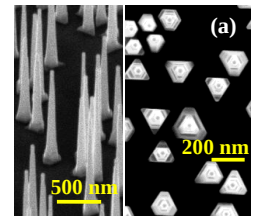
M. De Luca [1], S. Birindelli [1], A. Zilli [1], A. Polimeni [1], M. Capizzi [1], F. Mura [2], H. A. Fonseka [3], H. H. Tan [3] and C. Jagadish [3]

[1] *Dipartimento di Fisica, Sapienza Università di Roma, Italy*
[2] *Dipartimento di Scienze di Base e Applicate per l'Ingegneria, Sapienza Università di Roma, Italy*
[3] *Department of Electronic Materials Engineering, Research School of Physics and Engineering, The Australian National University, Canberra, Australia*

Semiconductor nanowires (NWs) are promising building blocks for next generation nanoscale devices [1]. The interest for these nanostructures stems from their exciting electronic properties and the possibility of controlling their synthesis. Indeed, the peculiar formation process of NWs, which involves vapor–liquid–solid mechanisms, enables switching from zincblende (ZB) to wurtzite (WZ) crystal phases, depending on growth conditions [2]. The presence of a WZ phase in the lattice structures of III-(As,P) semiconductors, notoriously stable in the ZB form as bulk, is one of the most surprising findings in these NWs and may lead to phase-modulated nano-WZ/ZB-structures along the wire axis.

Changes in the crystal phase create striking effects on the band-structure of InP NWs [3]. We use photoluminescence (PL) excitation spectroscopy (PLE) to investigate the density of states (DOS) of WZ InP NWs [see scanning electron-microscope, SEM, images in Fig. 1 (a)], whose PL spectrum [dashed line in Fig. 1 (b)] is characterized by sharp lines related to the free exciton and crystal defects.

The NW DOS, as it results from PLE (blue, solid line), exhibits several resonances (*A*, *B*, and *C*). We find an energy difference between WZ (resonance *A*) and ZB (1.42 eV, not shown) band-gaps equal to 70 meV. The selection rules due to the crystal symmetry and the polarization degree (ρ, red solid line) of the absorbed light, as determined from polarization-resolved PLE, allows us to nicely associate those resonances to the transitions sketched in the inset. In particular, transition *A* shows a polarization degree (ρ~0.85) remarkably higher than that of transitions *B* and *C*, consistently with the symmetry of the involved critical points. The deep minima that ρ exhibits at the energies of the excitonic resonances *A*, *B*, and *C* can be ascribed to a mixing of valence bands with different symmetries driven by the excitonic interaction. ZB InP nanowires have also been studied for comparison, and we will provide a clear picture of the DOS of these technologically relevant nanostructures.



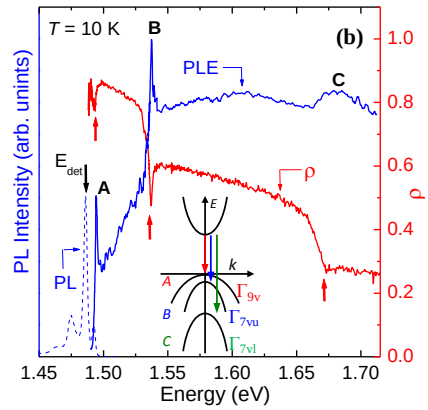


Fig. 1 (a) Side-view (left panel) and top-view (right panel) SEM images of WZ InP NWs. **(b)** PL (dashed line) and PLE (blue solid line, obtained by keeping the PL detection energy fixed at E_{det}, downward pointing arrow) spectra recorded in the same sample. The inset sketches the band diagram at the Γ point of WZ InP and the pertinent valence bands involved in transitions *A*, *B*, and *C*. At these energies, the polarization degree ρ (red solid line) shows deep minima (up-pointing arrows).

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