Carrier lifetime assessment in GaAs nanowire radial junctions by Time Resolved Cathodoluminescence

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The possibility to grow high structural quality III-V nanowires (NWs) on mismatched substrates such as Si, provides an elegant way to fabricate a III-V on Si tandem solar cell avoiding in one go the use of expensive III-V substrates and the difficult integration of III-V on Si. The success of this strategy relies on the precise control of the single NW crystal structure, doping and passivation, as an essential element for the development of nanowire-based optoelectronic devices.

Standard macroscopic characterization techniques such as X-ray diffraction, effect Hall measurements or photoluminescence are difficult to implement on a single NW or they averaged over millions of nano-objects. On the contrary, Cathodoluminescence (CL) microscopy allows for mapping the luminescence at the nanoscale and this signal can be used to extract a number of important parameters in single NWs. In previous works, we have demonstrated the use of CL for the determination of the doping concentration in single n-type (Si-doped) and p-type (Be-doped) GaAs NW.[1, 2]

In this contribution, we address the problem of NW passivation using time-resolved CL (TRCL) microscopy in order to assess the carrier lifetime at different locations of a single NW. Self-catalyzed GaAs NWs are grown on Si substrate by molecular beam epitaxy using the vapor-liquid-solid method. Under particular grow conditions, we are able to select the NW crystal structure and fabricate NWs containing large segments of zinc-blende (ZB) or wurtzite (WZ). In a preliminary study we use CL polarimetry to identify the crystal structure and we use TRCL to selectively measure carrier lifetimes in the two different segments of the GaAs NW (Figure). The work is further extended to the systematic study of passivation in complete GaAs radial homojunctions and GaAs/InGaP radial heterojunctions with different passivation layers.

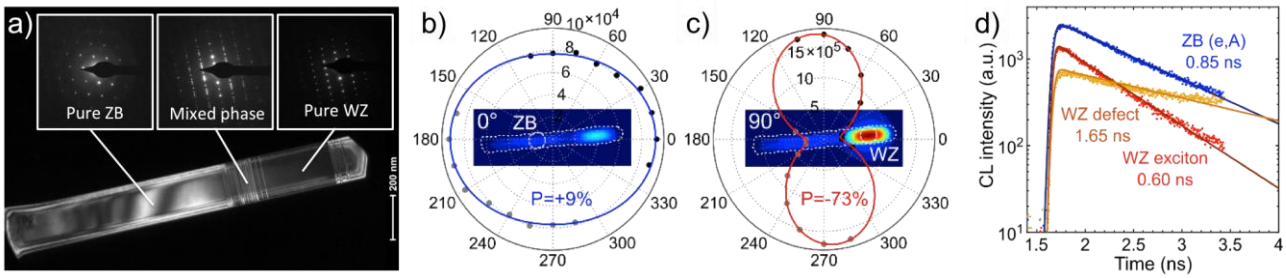

Figure – Dark field TEM image of a GaAs NW. (a) Polar plot of the CL intensity extracted from: pure ZB (b) and pure WZ (c) region of the NW as a function of the polarizer angle. Time decay of the luminescence in the ZB segment (blue) and ZB segment for energies corresponding to the exciton (red) and the defects (orange).

[1] H.-L. Chen et al., "Determination of n-type doping level in single GaAs nanowires by cathodoluminescence", Nano Letters 17, 6667 (2017)
[2] H.-L. Chen et al., "Quantitative Assessment of Carrier Density by Cathodoluminescence (2): GaAs nanowires" http://arxiv.org/abs/1909.05602