Nanowires Are Not So Cool

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In optoelectronic and thermoelectric devices based on semiconductor nanowires (NWs), a pivotal role is played by the carrier cooling and heat management mechanisms. For instance, the reduced thermal conductivity of NWs with respect to their bulk counterparts has enabled an increase in the figure of merit of thermoelectric devices. Also, the rate at which charge carriers cool down after an optical or electrical excitation is crucial in relation to the efficiency of solar cells and high-speed devices. So far, surface roughness[1] and polytypism,[2] as well as several point defects, have been invoked as possible mechanisms able to hamper carrier-phonon interaction usually driving carrier thermalization.

We investigate the thermalization properties of charge carriers in InP NWs.[3] Photoluminescence (PL) measurements on single NWs and NW ensembles highlight the existence of a difference (ΔT) between the temperature of photo-generated carriers (T_C) and that of the lattice (T_L). Figure 1 (a) and (b) show PL spectra (thick lines) recorded at room temperature on some WZ and ZB NWs with diameters d, respectively. T_C is estimated by the fitting curves to PL spectra (dashed lines) that include both excitonic and continuum states. Clearly, T_C increases with decreasing d, as also summarized in (c). T_C as high as 500 K is reached at T_L=310 K in NWs with the smallest d. This hot carrier phenomenon is found to be a general feature of NWs regardless of NW growth technique (vapour-liquid-solid *vs* catalyst-free selective area epitaxy), crystal structure (WZ *vs* ZB), and shape. Thus, charge carriers in NWs can harvest a thermal budget up to the long times probed by steady-state PL spectroscopy that is of relevance for photovoltaic and thermoelectric applications.

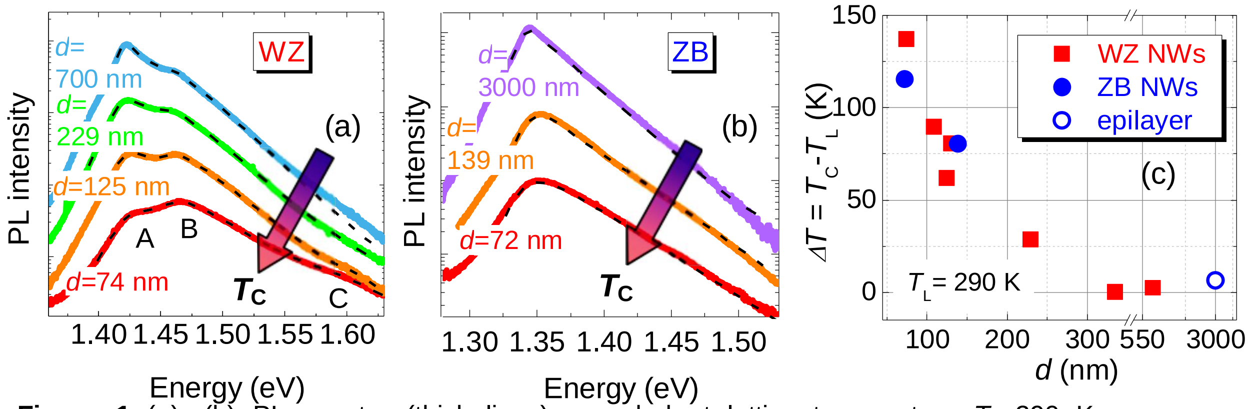

Figure 1 (a), (b) PL spectra (thick lines) recorded at lattice temperature T_L=290 K on some representative WZ (a) and ZB (b) InP samples with the indicated diameter d. Notice the semilog scale, allowing to roughly estimate carrier temperature T_C from the slope of high-energy tails. T_C was actually estimated by the fits of PL spectra (dashed lines). In WZ samples, high-energy transitions (labelled B and C) get more populated as T_C increases. (c) $\Delta T = T_C - T_L$ *vs* d estimated at T_L=290 K for all WZ (squares) and ZB (circles) samples.

References

[1] A. I. Hochbaum, *et al.*, *Nature.* **451**, 163 (2007).
[2] Y. Wang, *et al.*, *Nano Lett.* **14**, 7153 (2014).
[3] D. Tedeschi, *et al.*, *Nano Lett.* (to be submitted).