Ultrafast hot electron dynamics in InAs nanowires with variable crystal phases investigated by time-resolved photoelectron emission microscopy

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The III-V nanowire (NW) technology platform has reached a level of advancement that allows atomic scale tailoring 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[1]. We have previously found that multiphoton electron excitations can be controllably varied across the NW crystal segments [2] and that segments retain their unique electronic properties to the smallest possible scales[3]. In the present study we employ ultrafast time resolved PEEM utilizing femtosecond laser sources to explore the initial stages of the photo-carrier relaxation dynamics in InAs nanowires consisting of segments with different crystal structure. To this end, we combine PEEM with a tunable femtosecond laser source delivering sub 20fs pulses in the visible spectral range and perform spatially resolved one-color pump-probe measurements on individual nanowires. The photoelectron yield is found to increase within approximately 100fs after excitation, followed by an exponential decay with a dominant time constant of about 400fs. We tentatively attribute these signals to the thermalization and the cooling of the photo-excited electrons. Furthermore, we demonstrate local variations of the relaxation times within individual nanowires as a function of excitation light polarization and crystal structure.

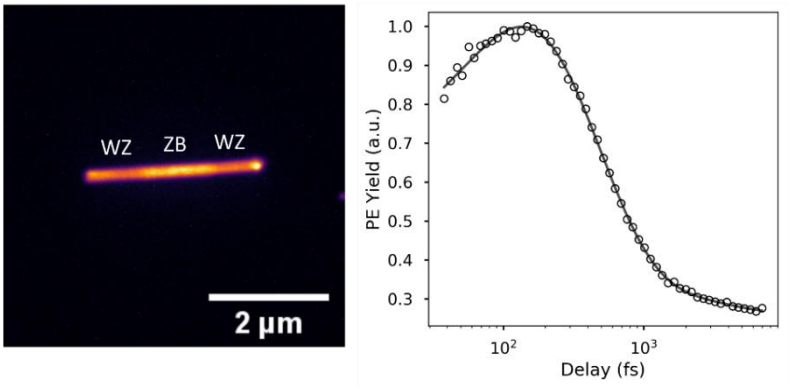

Figure 1. Left: UV-PEEM image of an InAs nanowire consisting of three segments with wurtzite or zinc-blende crystal structure (4.9 eV photon energy). Right: Photoelectron yield from the nanowire as a function of pulse delay for a typical pump-probe experiment.

[1] D. Jacobsson et al, Nature, 531 (2016) 317
[2] J.V. Knutsson et al, ACS Nano, 11 (2017) 10519
[3] E. Mårsell et al, Nano Lett. 18 (2018) 907

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