Electron-hole symmetry in GaSb/InAs core/shell nanowires

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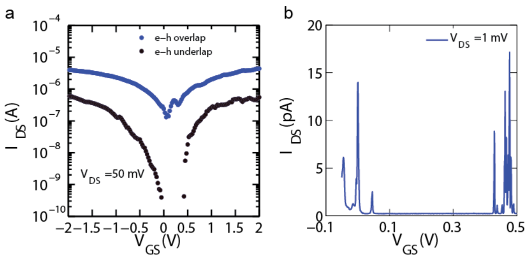
The GaSb/InAs heterostructure has been investigated for various device implementations since the first pioneering work by Sakaki et al in the late 1970s [1]. In bulk, GaSb and InAs are among the semiconductors with the highest hole and electron motilities, respectively. The structures have shown promise for high speed electronic devices and photonic applications in the infrared region [2]. The heterostructure has recently gained a lot of interest as an important system for fundamental studies of quantum physics (e.g. recently in the search for Quantum Spin Hall effect and topological insulators) [3]. Theoretical and experimental studies show the presence of a hybridized mini-gap in GaSb/InAs heterostructure due to conduction and valance band overlap in InAs and GaSb, respectively. Novel quantum devices, such as 1D topological insulators, could be realized by combining the broken gap (semimetal) alignment of a GaSb/InAs heterostructure and the one-dimensional nature of a nanowire. We report on transport modulation in top-gated GaSb/InAs core/shell nanowire field-effect transistors. Comparing the transfer characteristics of the devices with different shell thicknesses it was found that the thickness of the shell had a strong effect on the semiconductor properties. We show that carrier concentrations and majority carrier type could be tuned, from *p* to *n* type, by varying the InAs thickness. A particularly interesting regime was found for nanowires with an InAs shell thickness in the range 4-6nm, which exhibit ambipolar conduction with a finite resistance at charge neutrality point at T= 4.2 K. At this point electrons and holes seem to coexist, which can be a signature of a negative band gap and electron-hole hybridization. However, nanowires with slightly thinner InAs shell show a small insulating region, which is a signature of a staggered band alignment, for which the resistance increases significantly when the Fermi level is positioned in the band gap. .

Figure 1: (a) transport properties of two different NWFETs with negative and normal band gap at 4.2 K. (b) Charge oscillations at V_{DS}= 1 mV, and T = 4.2 K for a device with electron- hole underlap, where the transport is tuned from single-hole tunneling, to single-electron tunneling



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