Correlating structural and electrical properties of Selective Area Grown InAs nanowires

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InAs nanowire-based field effect transistors (NWFETs) are promising candidates for ultra-low-power electronics and quantum information processing applications due to their high carrier mobility when compared to NWs based on other materials as well as intrinsic confinement making it particularly attractive for use in cryogenic electronics. Using a patterned SiO_2 mask, we report on selective area growth (SAG) of InAs nanowires on GaAs(Sb) buffer layers [1], using molecular beam epitaxy (MBE). This platform is used to define quasi-1-dimensional semiconductor nanowire (NW) arrays. The development of large scale integrated (LSI) circuits incorporating many interacting such devices requires potential materials to exhibit high-precision reproducibility and scalability. However, large scale characterization of electronic transport properties has not been as feasible as optical techniques such as μ-photoluminescence. To demonstrate that the NWs developed based on the selective area growth (SAG) approach are a promising platform for quantum electronics due to the possibility of controlled growth of large-scale arrays, the first demonstration of LSI circuits based on InAs SAG NWs has been made.

A multiplexer-demultiplexer (MUX/d-MUX) set-up is realized for the electrical characterization of NWFET devices [2]. Electrical characteristics such as the threshold voltage (V_{th}) and field effect mobility (μ_{FE}) of 256 nominally identical NWFET devices are quantified with a statistical significance. Corresponding reproducibility in structural characteristics of 180 NWs is quantified using atomic force microscopy as the primary tool. Furthermore, the dependence of the NW morphology on the SAG mask dimensions such as width (W) and in-plane orientation (θ) is discussed with supplementary results from HAADF-STEM and EELS of select NW dimensions. Varying W gives us the opportunity to the study the different stages of InAs growth, whereas varying θ allow us the track the influence of the unintentional mis-orientation associated with SAG substrate manufacturing [3]. The dependence of electrical transport characteristics on the NW dimensions such as width and in-plane orientation in terms of structure and morphology is discussed and a correlation with the structural characteristics is demonstrated.

References

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