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Electronic transport in semiconductor nanowires: physics studies and possible device applications[1]

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Semiconductor nanowires are attractive for physics as well as for applications due to the highly ideal character of their electronic and structural properties. We grow our III-V nanowires by what can be described as guided self-assembly, by which we can accurately control location as well as dimensions of epitaxially nucleated nanowires. The level of control of growth allows controlled formation of axial as well as radial heterostructures. I will describe studies of charge transport via single, double and multiple quantum dots positioned inside InAs/InP nanowires. Such studies have allowed detailed studies of the addition of electrons one-by-one, from the very first electron into an empty quantum dot to the addition of up to 50 electrons. By replacing the one-dimensional emitter by a small quantum dot in a double-dot configuration, the discrete character of the injecting state allows ever more detailed spectroscopic studies of the charge additions to the second dot. Comparisons will be made with transport through quantum dots defined by tunnel barriers induced via gating techniques. Finally, a recently developed technique for the formation vertical wrap-gate field-effect transistors around InAs nanowires will be described, suggesting interesting opportunities for the realization of high-speed and low-power transistors and circuits. The geometrical design of such nanowire wrap-gate field-effect transistors, offers exciting ways of formation of ultra-short transistor gate-lengths as well as the use of heterostructures to further enhance the performance of such devices.

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