

Exploring the GaSb quantum dot

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One of the recent popular topics regarding future electronics is an universal quantum computer. The benefits of such quantum computers are their ability to perform certain calculations significantly faster than even the current generation of supercomputers. One expects that a quantum computer can solve the task in a few seconds where your personal computer will never solve it until at the end of the world. One proposed a key component of a qubit, the smallest unit of a quantum computer are quantum dot. A quantum dot is an artificial system which restrict the motion of charge carriers, responsible for what we know as current, in all dimensions and is thus also referred to as a zero-dimensional system. In such small systems, charge transport obeys different laws compared to common bulk materials, where their motion remains unrestricted. In the quantum dot, charges are strongly confined and repel each other by coulomb repulsion. By supplying or removing additional electrostatic energy from these systems via variation of a voltage applied to a so called gate electrode coupled into the system, this effect can be used to control the current flow across the quantum dot. This kind of device is called single electron or hole transistor, depending on whether the transported charges are electrons or holes. Whether electrons or holes serve as charge carriers depends on the semiconductor material used in the device. We are looking into the single hole transistor in this project where the charge transport is taken by hole.

According to the previous research, one observes that hole-spins has much longer life span than electron-spin in quantum dots which means that it is more beneficial to study p-type semiconductor nanowire where the charge carrier is taken by hole. For this reason, in this project GaSb, a native p-type semiconductor where holes dominate transport is studied as host material for quantum dots. To date, GaSb has only received very little attention as possibly host system for qubits.

We are exploring with the behaviour of hole transport and spin in p-type quantum dot in GaSb nanowires. A nanowire is a high-aspect ratio wire with a diameter a hundred times smaller than that of human hair. Based on these nanowires, we study how devices should be designed to form and study quantum dots in GaSb. The nanolund provides all the necessary equipment for the fabrication of quantum dot and we expect to produce the high quality of SHT device. The results from this project will be starting point on the map to build the prototype of GaSb based quantum computer.