Coulomb Interactions and Charge Storage in Self-Assembled CdTe Quantum Dots

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Quantum dots (QDs) in charge-tunable structures are promising candidates for many novel devices such as quantum logic gates and single electron spin memories. The system also offers a unique possibility of studying QD morphology via the quantum confined Stark effect, which magnitude reflects charge distributions inside the dot. There is a large number of reports on charge-tunability, Stark spectroscopy, charge storage, and Coulomb blockade in III-V nanostructures, but papers considering II-VI systems are scarce, although obtaining occupation control of a magnetically doped II-VI QD is expected to provide electrical tuning of its magnetic properties.

In this report, we show results of photoluminescence experiments on QDs embedded in two types of structures: Schottky diodes and *p - i - n* junctions. From the magnitudes of Stark shifts we are able to infer values of the built-in dipole moment and electron-hole polarizability. We find that the sense of the dipole vector depends on the size of the dot: in large (small) dots it is parallel (antiparallel) to the growth axis. Polarizability values are roughly an order of magnitude smaller than in III-V QD reflecting a stronger exciton binding in more polar II-VI compounds. We observe an important decrease of the dipole moment upon dot charging. The decrease is larger in the case of charging with a hole than with an electron, which allows us to assume that repulsion between holes is stronger than between electrons. Moreover, analysis of charged excitons binding energies lets us conclude that electron-hole Coulomb attraction dominates over the repulsive interactions.

Our experimental results are supported with theoretical calculations. The dot is modeled as a disc with infinite barriers. Electron and hole energy levels are accounted for in a model based on effective mass approximation. Exciton transition energies are calculated using a full configuration interaction method. The results are in qualitative agreement with the experimental data.

Additionally, we demonstrate charge storage in an ensemble of dots. By proper modulation of the exciting laser and the bias voltage, we are able to optically write, store, and electrically read-out the accumulated charge. We investigate the storage time, which exceeds 10 ms and study the switching dynamics of the system, which occurs on the timescale of ~100 ns.