Electric manipulation of the charge state in the II-VI solotronic devices

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The recent development of quantum technologies in solid state such as spintronics and solotronics, as well as their potential utilization for quantum computing, requires a thorough understanding and control of the material spin properties. The ultimate quantum limit in this context is a single impurity interacting with the host semiconductor lattice and available carriers. At the same time, zero-dimensional structures such as epitaxial quantum dots (QDs) are a relatively simple model system to conveniently probe fundamental interactions in condensed matter. As a consequence, QDs have been used for determining the spin and charge properties of single magnetic ions [1,2,3,4].

Magneto-optical measurements are often performed to reveal the particular properties of a QD doped with a single magnetic ion. This gives access to detailed information about the interaction of a single ion with the crystal lattice, (such as the energies and splitting of different spin states in the presence of strain), confined carries, (like the s,p-d interaction constants) and magnetic field, (like the g-factor values). An introduction of an external electric field can allow for switching between different charge states of the QD, as indicated by the occurrence of a variety of charged exciton transitions. Moreover, this procedure also introduces Stark shift, which provides a possibility to tune the QD transition over a range of energies. This is particularly useful for satisfying resonant excitation conditions which are often required in advanced experimental schemes, e.g. resonant fluorescence experiments or for the optical control and preparation of the dopant's spin state. In this work, we develop a method for controlling the charge state of a single magnetic ion inside an epitaxial II-VI QD by simultaneously applying electric and magnetic fields to the sample.

We probe two systems of II-VI epitaxial QDs: based on tellurides (doped with Ni) and selenides (doped with Fe), placed inside the Schottky diode device. We find that, for the case of CdTe QDs, we efficiently tune the exciton transitions energies by the application of an external electric field which introduces up to 20 meV shifts by the Stark effect. We are also able to manipulate the average charge state of the QDs up to the limit of charge separation which leads to the effect of exciton breaking. For the CdSe QDs we observe different behavior. Their photoluminescence lines have almost constant energies. By applying voltage we are able to change their intensity and switch on and off some of the charged excitonic complexes. The demonstrated ability of electric manipulation of the charge state of the II-VI QDs in both systems is highly promising for single magnetic dopants investigations.

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[3] T. Smoleński et al, *Nat. Commun.* **7**, 10484 (2016).
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