HL 20 Symposium: Single Photon Sources and Spectroscopy of Individual Quantum Systems

Zeit: Samstag 10:45–13:15 Raum: TU P270

HL 20.1 Sa 10:45 TU P270

Read-out and manipulation of single electron and nuclear spins and spin pairs — •J. Wrachtrup — University of Stuttgart, Stuttgart, Germany

Optically accessible defects in semiconductors with large band gap show a number of properties which make them interesting candidates for a controlled engineering of quantum states in solids [1]. The talk will concentrate on color centers in diamond. One of the particularly interesting defects, the nitrogen vacancy defect center, has an electron spin paramagnetic ground state. The fluorescence of this defect strongly depends on the spin state of the electron. Single defect centers can be isolated by optical microscopy. It was shown that the spin state of a single defect center can be determined by optical spectroscopy. Microwave and radiofrequency irradiation allows to manipulate single electron and nuclear spins (for example nitrogen and ^{13}C) [2,3]. One can create arbitrary spin quantum states, for example Bell states, and probe its dephasing behavior. The talk will describe similar experiments in which for example nanopositioned defect centers are entangled.

[1] F. Jelezko and J. Wrachtrup J. Phys: Cond. Mat. 16 (2004) R1089

[2] F. Jelezko, T. Gaebel, I. Popa, A. Gruber, and J. Wrachtrup Phys. Rev. Lett. 92 (2004) 076401

[3] F. Jelezko, T. Gaebel, I. Popa, A. Gruber, and J. Wrachtrup Phys. Rev. Lett. 93 (2004) 130501

HL 20.2 Sa 11:15 TU P270

Solid-state single-photon-sources for quantum cryptography — •H. Weinfurter[1], Ch. Wang[1], Ch. Braig[1], P. Zarda[1], and Ch. Kurtsiefer[2] — [1]Department für Physik, Ludwig-Maximilians-Universität, D-80799 München — [2]Department of Physics, National University of Singapore, Singapore 117542, Singapore

Color centers in diamond turned out to be simple and reliable sources of single photons. Based on confocal microscope set-up, these sources can be operated at room-temperature without any sign of bleaching. For example the N-V (nitrogen-vacancy) center was already used in experiments on the complementarity principle and for quantum cryptography. Its disadvantages, in particular the broad emission spectrum, can be avoided when using different centers studied more recently. The talk introduces the method of creating single photons and gives an overview of experiments applying these novel sources.

HL 20.3 Sa 11:45 TU P270

Optically initialization of single spins in semiconductor quantum dots — •Jonathan Finley , Miro Kroutvar, Dominik Heiss, Max Bichler, and Gerhard Abstreiter — Walter Schottky Institut and Department of Physics, Technische Universität München, Am Coulombwall 3, 85748 Garching, Germany

We will demonstrate the reversible transfer from optical polarization to the spin orientation of single carriers in semiconductor quantum dots. Following resonant excitation of the ground state exciton using circularly polarized light and selective charge separation in specially designed Schottky photodiode structures, we convert photon polarization into carrier spin orientation. After a time delay Δ t (=5ns to 1ms) the spin polarization of stored charges is tested by electrically neutralizing the dots and detecting the intensity and polarization state of the resulting electroluminescence signal. For electron storage samples, the EL is > 80% circularly polarized at T = 1K with a helicity that directly reflects the optical excitation and vanishes following excitation with un-polarized light. Using such techniques, we have recently measured the electron spin T1 and its dependence on lattice temperature and magnetic field. It is shown to be extremely long (>25ms at 1K), decreasing with magnetic field with a clear B^{-5} exponent, demonstrating that spin flip at low temperatures is mediated by SO mixing of the Zeeman levels by single piezoelectric phonons. Electron spin dynamics will be contrasted with hole storage samples and prospects for optical single dot spin readout will be given.

HL 20.4 Sa 12:15 TU P270

Spectroscopy of single nanowire heterostructures — •V. Zwiller, M. Borgström, and A. Imamoglu — Institute of Quantum Electronics, ETH, 8093 Zürich, Switzerland

Quantum dots are often referred to as artificial atoms because of their atom like density of states, yielding sharp optical transitions. Unlike for atoms, quantum dots properties can be tailored by modifying their composition, shape and size. Devices based on single quantum dots enable new functionalities; one particularly exciting novel function is the generation of non classical light.

We will present results obtained on single GaAsP quantum dots grown in GaP nanowires. The wires were grown using 20 nm sized gold catalysts by the use of metal organic vapor phase epitaxy in the vapor liquid solid growth mode. Low temperature photoluminescence studies were performed on single wires under continuous and pulsed laser excitation.

Previously we demonstrated single photon generation in several material systems: InAs quantum dots in GaAs were used to generate single photons at around 920 nm, InP quantum dots in GaInP at around 680 nm and CdSe dots in ZnSe were used for the green region. The potential of these novel quantum dots embedded in wires will be compared to the conventional Stranski Krastanow quantum dots.

HL 20.5 Sa 12:45 TU P270

Voltage-Controlled Optics of a Single Quantum Dot — •Khaled Karrai[1], Alexander Högele[1], Stefan Seidl[1], Martin Kroner[1], Richard J. Warburton[2], Brian D. Gerardot[3], and Pierre M. Petroff[3] — [1]Center for NanoScience and Department für Physik, Ludwig-Maximilians-Universität, Geschwister-Scholl-Platz 1, 80539 München, Germany — [2]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh EH14 4AS, United Kingdom — [3]Materials Department, University of California, Santa Barbara, California 93106, USA

We show how the optical properties of a single semiconductor quantum dot can be controlled with a small dc voltage applied to a gate electrode. Using a newly developed high-resolution laser spectroscopy method we find that the transmission spectrum of the neutral exciton exhibits two narrow lines with about 2 micro-eV linewidth. The splitting into two linearly polarized components arises through an exchange interaction within the exciton. We show that choosing a gate voltage where the dot is occupied with an additional electron turns off the exchange interaction. In this regime, the negatively charged exciton has no dark states. Saturation spectroscopy demonstrates that the neutral and the negatively exciton behaves as a two-level system. Our experiments show that the remaining problem for preparing and manipulating excitonic quantum states in this system is possibly spectral fluctuation on a micro-eV energy scale.