HL 113: Quantum information systems II (with TT)

Time: Friday 9:30–10:45 Location: POT 151

HL 113.1 Fri 9:30 POT 151

Coherent pulse re-shaping in a semiconductor optical amplifier — •Mitra Pasche, Mirco Kolarczik, Yücel Kaptan, Nina Owschimikow, and Ulrike Woggon — Institut für Optik und Atomare Physik, Technische Universität Berlin, Germany

Recently it was demonstrated that Rabi oscillations in Quantum Dots (QDS) induce a laser pulse re-shaping in a semiconductor optical amplifier (SOA) at room temperature[1]. Here we present the results of a systematic investigation of the dependence of the pulse re-shaping on pulse power, detuning and the electrical injection level. The measurements are performed using frequency resolved optical short-pulse characterization by heterodyning (FROSCH)[1]. The method allows to observe simultaneously the amplitude and phase of the light field of the laser pulse relative to a reference pulse. In numerical simulations, we vary the parameters of the probe pulse and quantify their influence on the shape of the cross-correlation of the probe and reference pulse. We can thus assign characteristic phase jumps observed in the experiment to a coherent exchange of energy in the light-matter system.

[1] M.Kolarczik, N.Owschimikow, J.Korn, B.Lingnau, Y.Kaptan, D.Bimberg, E.Schöll, K.Lüdge, U.Woggon, *Nat. Commun.*, accepted (2013).

HL 113.2 Fri 9:45 POT 151

Ambient Temperature Spin Pumping of Silicon Carbide Quantum Defects — •Hannes Kraus[1], Franziska Fuchs[1], Daniel Riedel[1], Victor Soltamov[2], Dmitrij Simin[1], Stefan Väth[1], Andreas Sperlich[1], Pavel Baranov[2], Georgy Astakhov[1], and Vladimir Dyakonov[1] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, Germany — [2]Ioffe Physical-Technical Institute, St. Petersburg, Russia

Silicon carbide is best known as a high performance power electronics semiconductor, although intrinsic defects in this material, particularly silicon vacancies, are very promising for quantum information processing, photonics and magnetometry [1]. This is due to the defects' intriguing quantum properties: The SiC defect spin states can be initialized and subsequently read using optically detected magnetic resonance (ODMR), and the high-spin ground state of these defects can be selectively populated by optical pumping. Similar to a lasing system, this leads to a population inversion and, consequently, to a stimulated radio emission [2]. We show this effect also works at room temperature, which opens an interesting perspective to construct low noise, low cost and low maintenance solid state radio amplifiers. Another opportunity is the defect ODMR's dependence on magnetic field orientation and temperature, suggesting SiC applications in quantum sensing.

[1] D. Riedel et al., Phys. Rev. Lett. 109, 226402 (2012)
[2] H. Kraus et al., Nature Physics (2013), doi:10.1038/NPHYS2826

HL 113.3 Fri 10:00 POT 151

Silicon Vacancies in Silicon Carbide as a Vector Magnetometer — •Dmitrij Simin[1], Franziska Fuchs[1], Hannes Kraus[1], Victor Soltamov[2], Andreas Sperlich[1], Pavel Baranov[2], Georgy Astakhov[1], and Vladimir Dyakonov[1] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg, Germany — [2]Ioffe Physical-Technical Institute, 194021 St. Petersburg, Russia

The determination of both the magnitude and orientation of ambient magnetic fields has become a crucial convenience and safety factor in smartphones, spacecrafts, and satellites. Due to severe requirements for these devices, including compactness, temperature stability, and inexpensive fabrication, there are few devices that meet them all. In this study, we present a new approach, utilizing the spin properties of the silicon vacancies in silicon carbide [1]. Using room temperature optically detected magnetic resonance [2], we measure the change in optical emission due to vacancy specific electronic transitions that are dependent on the magnitude as well as on the direction of the external magnetic field. Using these relationships, we show how silicon carbide can be used as a compact and cost-effective solution for vector magnetometry applications with a good accuracy.

[1]Riedel et al.: Phys. Rev. Lett. 109, 226402 (2012)
[2]Kraus et al.: Nat. Phys., DOI 10.1038/nphys2826 (2013)

HL 113.4 Fri 10:15 POT 151

Spin defect engineering in silicon carbide using neutron irradiation — •Franziska Fuchs[1], Michael Trupke[2], Georgy Astakhov[1], and Vladimir Dyakonov[1] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg — [2]Vienna Center for Quantum Science and Technology, Atominstitut, TU Wien, A-1020 Wien

Atom-like defects in semiconductors are promising systems for spin-based quantum information applications. With its advanced growth and device technologies, Silicon carbide (SiC) is an eligible host for such defects, e.g. silicon vacancies (V_{Si}). This spin-$\frac{3}{2}$ system can be addressed and manipulated [1] and could serve as a room temperature source for single photons [2] or a room temperature maser amplifier [3]. With these applications in mind, one main challenge is to thoroughly create, isolate, and control the defects. Here, we report defect engineering of V_{Si} defects in SiC by means of neutron irradiation. Our photoluminescence measurements show that the defect density is well controllable via the irradiation dose. The irradiation flux has been varied over 10 orders of magnitude, from 10^8 to 10^{18} neutrons/cm^2. Two specific cases are of interest. The generation of the maximum V_{Si} concentration possible without destroying the crystal structure is required for the implementation of maser amplifiers. On the other hand, the creation of very few, isolated defects is crucial for the realization of single photon sources. [1] Riedel et al.: Phys. Rev. Lett. 109, 226402 (2012), [2] Castelletto et al.: Nat Mat 12 (2013), DOI 10.1038/namt3806 [3] Kraus et al.: Nat Phys (2013), DOI 10.1038/nphys2826

HL 113.5 Fri 10:30 POT 151

Mapping the D1-transition of Caesium by dressed-state resonance fluorescence from a single (In,Ga)As quantum dot — •Sven M. Ulrich[1], Markus Oster[1], Michael Jetter[1], Alban Urvoy[2], Robert Löw[2], Tilmann Pfau[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany — [2]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

Hybrid quantum systems combining semiconductor quantum dots (QDs) and atomic vapors promise interesting applications in quantum information technology. Recent research in this field has explored the resonant coupling between single GaAs QDs and Rubidium gas to generate e.g. frequency-stabilized non-classical emission ($\sim$ 780 nm) as well as slow light for qubit storage/retrieval operations.

As an alternative hybrid approach we use a cw laser-driven single (In,Ga)As QD (4 K) in the "dressed state" resonance fluorescence (RF) regime to address the D_1 transitions of atomic Caesium (Cs) vapor (300 K). QD-atom resonance is achieved by tuning the frequency of the dressing laser close to the QD ground state $\nu_0 \approx 335.116$ THz (894.592 nm) and shifting the narrow-band center and side channels of the QD Mollow triplet. Using this laser frequency controlled QD probe light for absorption measurements allows to precisely identify all four Cs hyperfine-split transitions. Therefore, narrow-band (In,Ga)As QD RF is demonstrated as suitable to optically address individual channels of the D_1 quadruplet without magnetic field or electric field tuning.