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Manipulating single electron spins and coherence in quantum dots[1]

DAVID AWSCHALOM[2], Center for Spintronics and Quantum Computation, University of California, Santa Barbara, CA 93106

The non-destructive detection of a single electron spin in a quantum dot (QD) is demonstrated using a time- averaged magneto-optical Kerr rotation measurement[3]. This technique provides a means to directly probe the spin off- resonance, thus minimally disturbing the system. Furthermore, the ability to sequentially initialize, manipulate, and read out the state of a qubit, such as an electron spin in a quantum dot, is necessary for virtually any scheme for quantum information processing. In addition to the time-averaged measurements, we have extended the single dot KR technique into the time domain with pulsed pump and probe lasers, allowing the observation of the coherent evolution of an electron spin state[4]. The dot is formed by interface fluctuations of a GaAs quantum well and embedded in a diode structure to allow controllable gating/charging of the QD. To enhance the small single spin signal, the QD is positioned within a vertical optical cavity. Observations of coherent single spin precession in an applied magnetic field allow a direct measurement of the electron g-factor and transverse spin lifetime. These measurements reveal information about the relevant spin decoherence mechanisms, while also providing a sensitive probe of the local nuclear spin environment. Finally, we have recently eveloped a scheme for high speed all-optical manipulation of the spin state that enables multiple operations within the coherence time[5]. The results represent progress toward the control and coupling of single spins and photons for quantum information processing[6] as well as quantum non-demolition measurements of a single spin.

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[2]In collaboration with M. H. Mikkelsen, J. Berezovsky, N. G. Stoltz, and L. A. Coldren
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