Quantum control and engineering of single spins

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ABSTRACT

Eighty years since Dirac developed the quantum theory of electron spin, contemporary information technology still relies largely on classical electronics: the charge of electrons for computation and the magnetic materials for permanent storage. There is a growing interest in exploiting spins in semiconductors for the manipulation and storage of information in emergent technologies based upon spintronics and quantum logic. Recently, localized electronic states of carbon-based materials have appeared as a unique solid state platform for fundamental measurements at the single spin level. In diamond, the spins of individual nitrogen-vacancy (NV) color centers can be imaged and manipulated at room temperature and have remarkably coherence times. We perform gigahertz coherent control of individual NV center spins in a new dynamical regime [1], including spin rotation on the same timescale as the Larmor precession. We find strong hyperfine coupling with the intrinsic N nuclear spin, thus offering a potential resource for both quantum information processing and atomic storage [2]. In addition, we present a technique to nanofabricate single spins based on broad-beam nitrogen implantation through apertures in electron beam lithography resist. This method enables high-throughput nanofabrication of large scale spin arrays with ~50nm spatial accuracy [3]. By combining coherent spin control with resonant optical excitation we demonstrate non-destructive spin measurement and coherent spin manipulation through the optical Stark effect [4]. In contrast to destructive readout methods traditionally employed to measure spin states, these interactions preserve coherence and enable the coherent exchange of quantum information between spins and light. These results may facilitate coherent measurement, control, and entanglement that is scalable over large distances.

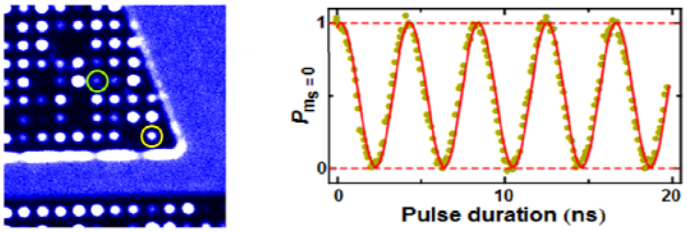

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FIGURE 1. Section of implanted spin array with microwave control line; 300K measurement of single electron spin coherence.

REFERENCES

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