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Quantum information processing with defect spins in diamond and silicon carbide[1]

WILLIAM KOEHL[2], Center for Spintronics and Quantum Computation, University of California, Santa Barbara, CA 93106 USA

Many proposals for quantum information technologies require quantum systems that can be easily manipulated by an outside observer, while remaining largely unaffected by destructive interactions with the surrounding environment. One system that matches this description is a defect in the crystal lattice of diamond known as the nitrogen-vacancy (NV) center. Electrons trapped at this defect form an atomic scale spin state that can be used as an individually addressable, solid state quantum bit (qubit) even at room temperature. The exceptional quantum properties of the diamond NV have motivated recent efforts to search for similar defects in other semiconductors, as these would expand the technological opportunities available to defect-based quantum systems [1]. We discuss these efforts, which make use of techniques from both computational materials science and experimental quantum physics, focusing on explorations of the 4H polytype of silicon carbide (4H-SiC). In particular, we present recent experimental results that identify several defect spin states in 4H-SiC that function as analogs to the diamond NV. Using optical and microwave techniques similar to those used with diamond NV qubits, the spins of these defects can be optically addressed and coherently controlled in the time domain at temperatures ranging from 20 – 300 K. Additionally, these defects are optically active near telecom wavelengths, inhabit a host material for which there already exist industrial scale crystal growth and advanced microfabrication techniques, and possess desirable spin coherence properties comparable to those of the diamond NV. This makes them promising candidates for various photonic, spintronic, and quantum information applications that merge quantum degrees of freedom with classical electronic and optical technologies [2].

[1] J. R. Weber*, W. F. Koehl*, J. B. Varley*, A. Janotti, B. B. Buckley, C. G. Van de Walle, and D. D. Awschalom, *Proc. Natl Acad. Sci. USA* **107**, 8513 (2010).
[2] W. F. Koehl, B. B. Buckley, F. J. Heremans, G. Calusine, and D. D. Awschalom, *Nature* **479**, 84 (2011); A. Dzurak, *Nature* **479**, 47 (2011).

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