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Quantum information processing with spins in diamond and silicon carbide

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A strong motivation behind modern research into quantum physics has been to identify robust quantum states that can be easily controlled, for future use in advanced information technologies. During the past few years, an optically active point defect in diamond known as the nitrogen-vacancy (N-V) centre has attracted a great deal of interest because it possesses an atomic scale electronic spin state that can be used as an individually addressable, solid state quantum bit (qubit) even at room temperature. The N-V center's optical transitions become coherent, spin-dependent, and may be precisely controlled with gate voltages in micron-scale devices, with promise for future photonic applications [1]. Moreover, engineered coupling of this electron spin with the proximal single nitrogen nuclear spin enables a scalable quantum memory [2]. These exceptional coherent properties have motivated theoretical efforts to predict and identify similar defects in other semiconductors, since they may offer an expanded range of functionality not available to the diamond N-V [3]. We show that several defect spin states in various polytypes of SiC can be optically addressed and coherently controlled in the time domain at temperatures ranging from 20 –300 K. Using optical and microwave techniques similar to those used with diamond N-V qubits, we study the ground states of the neutral carbon-silicon divacancy. These defects are optically active near telecom wavelengths, and inhabit a host material for which there already exist industrial scale crystal growth and advanced microfabrication techniques. In addition, optical spectroscopy and spin resonance measurements reveal that they possess desirable spin coherence properties comparable to those of the diamond N-V. 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 [4].

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