Electrical Detection of Coherent Spin States in a Silicon Carbide Device

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Silicon carbide (SiC) is a complimentary metal-oxide-semiconductor (CMOS) compatible wide bandgap semiconductor most notably used in high-voltage, high-power, and high-temperature applications [1]. SiC also shows considerable promise as a materials platform for the development of a wide range of quantum applications, including quantum communications and quantum sensing [2]. A range of defects in SiC have spin states that can be addressed optically and in some cases electrically, offering the spin degree of freedom for quantum information processing. These defect centres coupled with existing mature fabrication protocols developed for SiC microelectronics provide a straightforward path toward viable, cost-effective, and scalable integrated quantum devices. When present in a pn-junction device, some deep-level defects centres in SiC can facilitate spin-dependent recombination (SDR), providing a sensitive electrical pathway for the detection of the spin state [3].

In this work, we present our recent results on the electrical detection of coherent spin manipulation of SDR in a SiC pn-junction device at room temperature via pulsed electrically detected magnetic resonance (pEDMR). Technical challenges associated with the pEDMR technique are addressed by implementing a multi-level modulation scheme for lock-in detection, enabling the observation of Rabi oscillations and spin-beating on a small ensemble of spins. The experimental results demonstrated here are an important step toward the realisation of future SiC quantum devices.

[1] T. Kimoto and J. A. Cooper, *Fundamentals of Silicon Carbide Technology: Growth, Characterization, Devices and Applications*. John Wiley & Sons (2014)

[2] M. E. Bathen, C. T.-K. Lew, J. Woerle, C. Dorfer, U. Grossner, S. Castelletto, and B. C. Johnson, *Characterization methods for defects and devices in silicon carbide*. Journal of Applied Physics **131**, 14 (2022)

[3] C. Boehme and K. Lips, *Time domain measurement of spin-dependent recombination*. Applied Physics Letters **79**, 26 (2001)