Photoionisation detection of a single erbium ion with sub-100-ns time resolution

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Efficient detection of single optical centres in solids is essential for quantum information processing, sensing and single-photon generation applications. The early success of nitrogen-vacancy (NV) centres in diamond relies on strong, spin-dependent fluorescence as well as the cyclic optical transitions [1] but is limited by the photon collection efficiency and spin-flip errors during the optical readout. the number of collected photons is used as the readout signal. Therefore, the readout fidelity is limited by spin-flip errors, which occur during repeated excitations for getting sufficient signal contrast, and by the photon collection efficiency, despite the improvement due to the use of a solid-immersion lens.

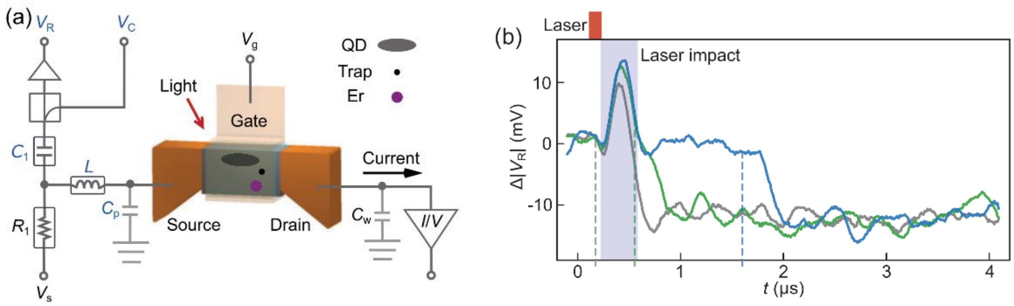

Fig. 1 (a) Experimental setup for the photoionisation detection.
(b) Three typical signal-time traces measured from a single erbium ion. [2]

We demonstrate fast photoionisation detection of single erbium ions in a Si nano-transistor using RF reflectometry, as shown in Fig. 1. At an analog bandwidth of 2 MHz, this technique provides a SNR of 9.6 with an integration time of 0.5 μs and a photoionisation detection time resolution below 100 ns. The fast detection enables $^4I_{13/2}$ excited state lifetime measurements for single erbium ions in a Si nano-transistor.

The photoionisation detection of single erbium ions relied on erbium-induced ionisation of a nearby trap; however, the charge state change observed from NV centres in diamond [3,4] and single defects in SiC [5] could be directly detected by a charge sensor without involving an additional trap. Therefore, RF reflectometry provides a promising direction forward for scalable optical quantum systems.

References

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