Study demonstrates fast photoionization detection of single erbium ions in silicon

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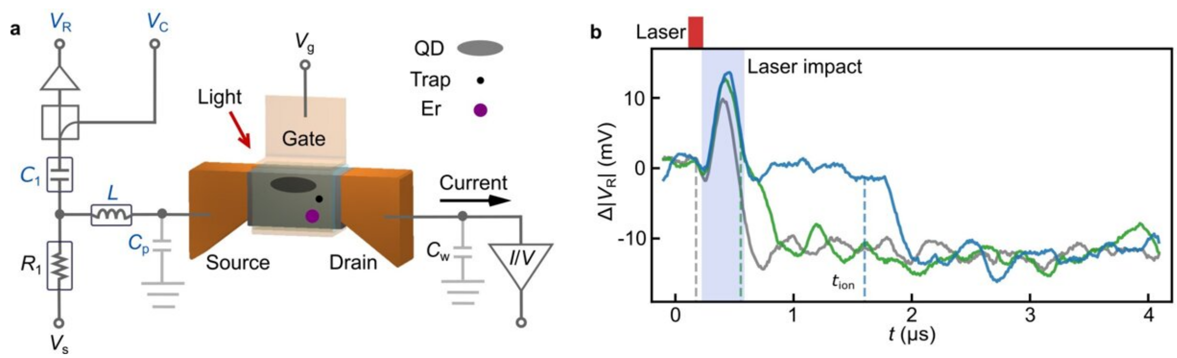

A) Fast photoionisation detection of single Er^{3+} ions in a silicon nano-transistor. b) Three photoionisation events detected on a single Er^{3+} ion (Fig. 1b). Credit: Science China Press

Efficient detection of single optical centers is crucial for applications in quantum computing, sensing, and single-photon generation. For example, nitrogen-vacancy (NV) centers in diamond have made breakthroughs in high-precision magnetic field measurement. The detection of NV centers relies on observing their spin-correlated fluorescence.

Similarly, optical centers in silicon carbide and rare earth ions in solids also have similar detection mechanisms. However, the readout of these systems requires collecting a sufficient number of photons as detection signals, which limits the fidelity of spin state readout. In contrast, the electrical readout methods commonly used in quantum electronic devices provide higher readout fidelity within shorter time intervals.

A research team led by Prof. Chunming Yin at University of Science and Technology of China has recently achieved progress in the field of silicon-based quantum technology by demonstrating fast photoionization detection of single Er^{3+} ions in a silicon nano-transistor. The results have been published in the journal *National Science Review* and the first author of this article is Dr. Yangbo Zhang.

Prof Chunming Yin and his collaborators first achieved photoionization detection of single Er^{3+} ions in silicon-based single-electron transistors in 2013. However, the readout speed of photoionization events was significantly limited by the bandwidth of DC current measurements.

In this latest work, they employed radiofrequency reflectometry and successfully realized fast photoionization detection of single Er^{3+} ions in silicon-based single-electron transistors, and each ionization event can be detected with a time resolution better than 100 nanoseconds. Based on this technique, they also investigated the optical excited state lifetime of single Er^{3+} ions in silicon-based nanodevices.

Using the radiofrequency reflectometry detection technique on single optical centers provides new possibilities for scalable optical quantum systems. Moreover, this method holds promise for achieving rapid readout of other single optical centers in solids, thereby advancing the applications of single optical centers in scalable quantum systems and high-precision sensing.

More information: Yangbo Zhang et al, Photoionisation detection of a single Er3+ ion with sub-100-ns time resolution, *National Science Review* (2023). DOI: 10.1093/nsr/nwad134

Provided by Science China Press

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