Si quantum dots with counted Sb donors

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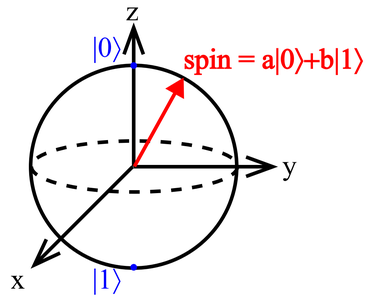
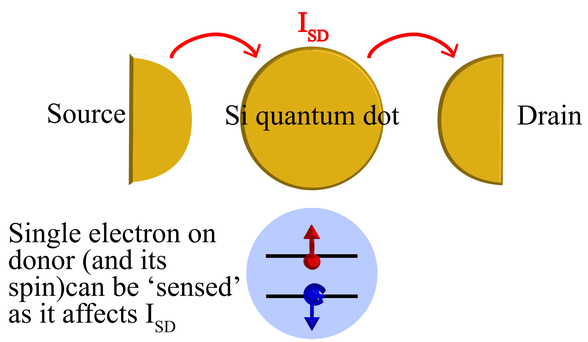
MOTIVATION

The spin of a single electron is the quintessential qubit.



qubit represented by the spin of a single electron

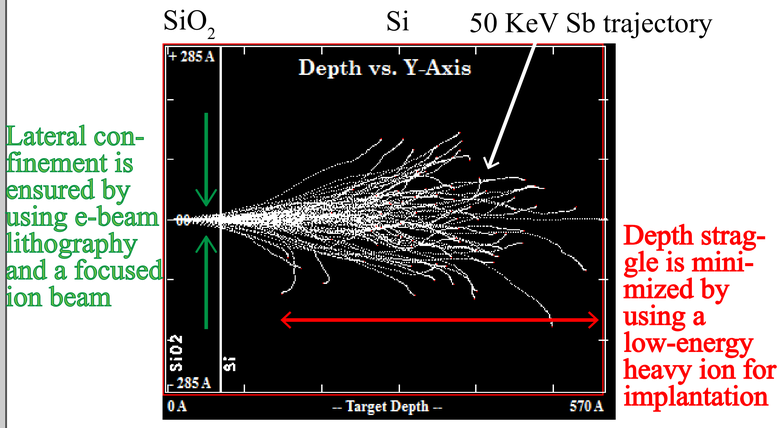
Coherence times and scalability determine the physical systems in which such a qubit can be implemented. Donors in Si are one viable candidate in which single qubits have been succesfully demonstrated.[1]



Our goal is to demonstrate multiple qubit interactions in donor spin qubits. To achieve this, precise placement and deterministic control over number of donors is required.

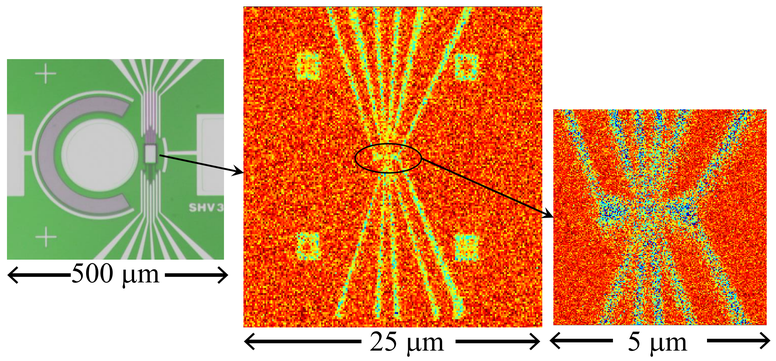
METHODS

1. Well localized donors are implanted into a Si substrate next to a MOS quantum dot using a focused ion beam system.



SRIM simulation showing 50 KeV Sb ions striking a Si substrate with a 7 nm thick SiO_2 layer.

2. The number of donors are counted using a single ion detector.[2]

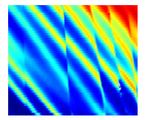


(a) Optical image showing nanostructure and avalanche photodetector (APD), (b) and (c) maps of nanostructure generated by measuring the ion beam induced current (IBIC) in the APD when sample is hit by 50 KeV Sb+ ions. The IBIC ∝ number of ions.

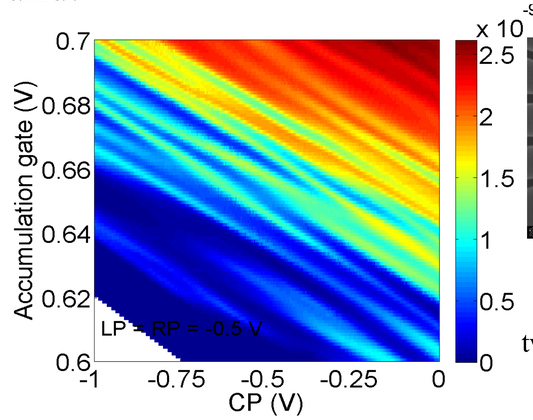
3. Low temperature transport measurements are performed

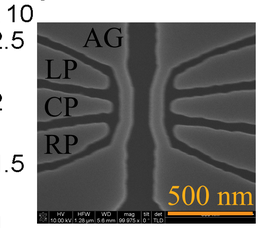
RESULTS

A donor transition is identified by a charge offset in the transport characteristics of the quantum dot. In control samples with no donor implant, no charge offsets are found.



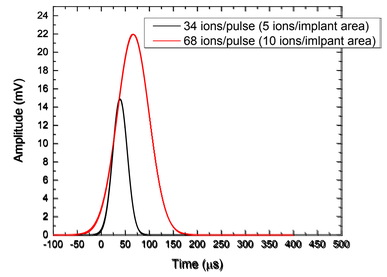
example of offsets in an unrelated sample





Scanning electron micrograph and transport at 2K of two control samples

Samples with 5, 10 and 20 counted Sb implants have been synthesized and are being measured.



Voltage response of ion detector when 5 and 10 ions are implanted in the region of interest

These results are necessary first steps towards fabricating donor nanostructures for two qubit interactions.

REFERENCES:
1. A. Morello et al., Nature 467, pp. 687 (2010)
2. J. A. Seamons et al., APL 93, 043124 (2008)

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