Transport Measurements in Silicon Quantum Dots with Counted Antimony Implants

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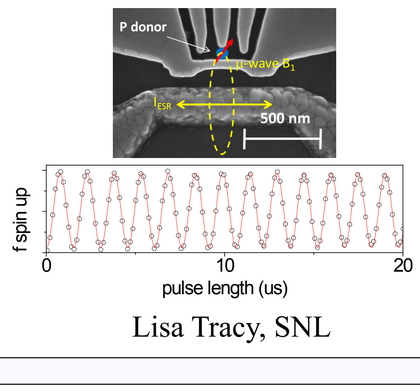
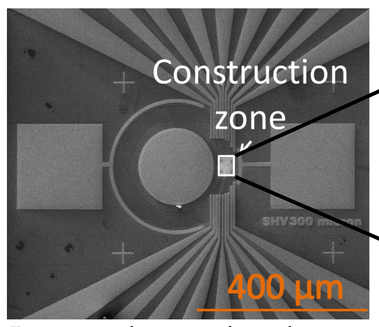
MOTIVATION

- Donor spins in silicon are promising qubits
- For universal quantum logic one needs - single qubit rotations and two qubit operations
- Single qubit control has been demonstrated on ^{31}P donors in ^{28}Si
- Two qubit operations require **deterministic control over donor number and location**

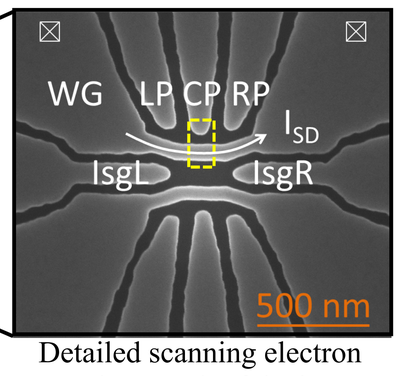


Lisa Tracy, SNL

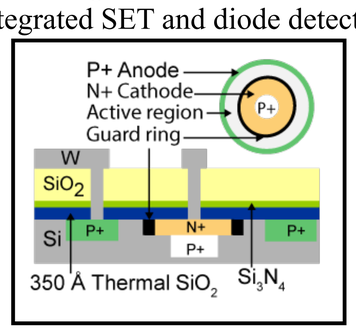
INTEGRATED DEVICE FABRICATION



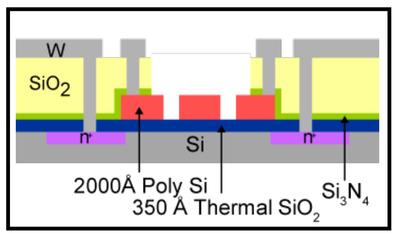
Large scale scanning electron micrograph of device with integrated SET and diode detector



Detailed scanning electron micrograph of device



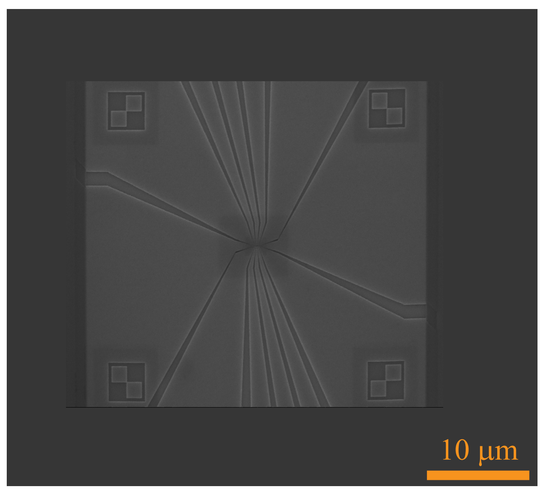
Schematics of cross section of diode detector

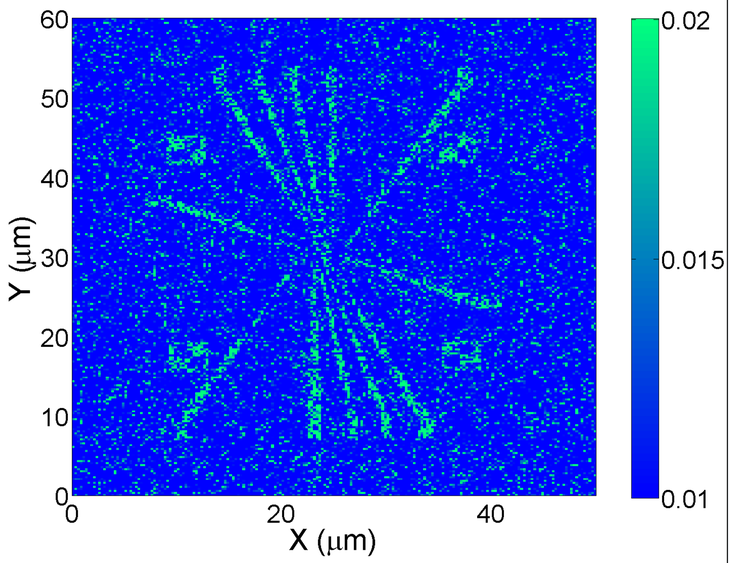


Schematics of cross section of gates for defining SET

Integrating detector with SET **allows counted implants**

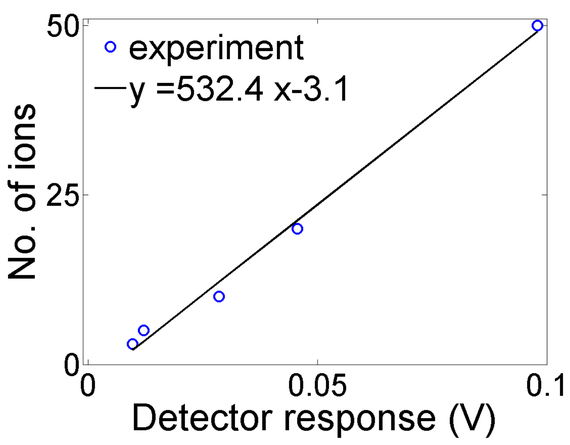
SINGLE ION DETECTION



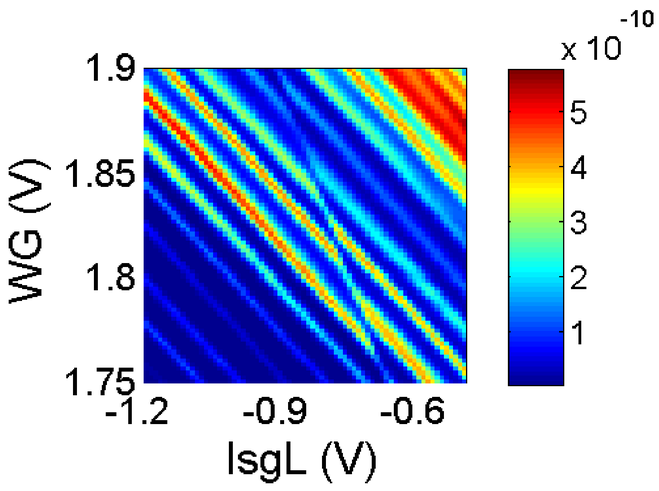


A scanning electron micrograph of the device (left) and an ion beam induced charge map (right) generated usingan average of 1 ion per pulse 120 keV Sb++ focused ion beam. This shows the detector is sensitive to a single ion.

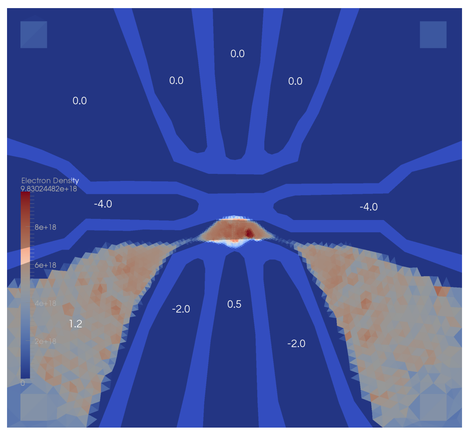
COUNTED IMPLANTS, TRANSPORT AND OFFSETS



For a given ion species, energy and device, the detector response is proportional to the number of ions incident. Using the calibration, **a device with counted 27 ions is fabricated**.



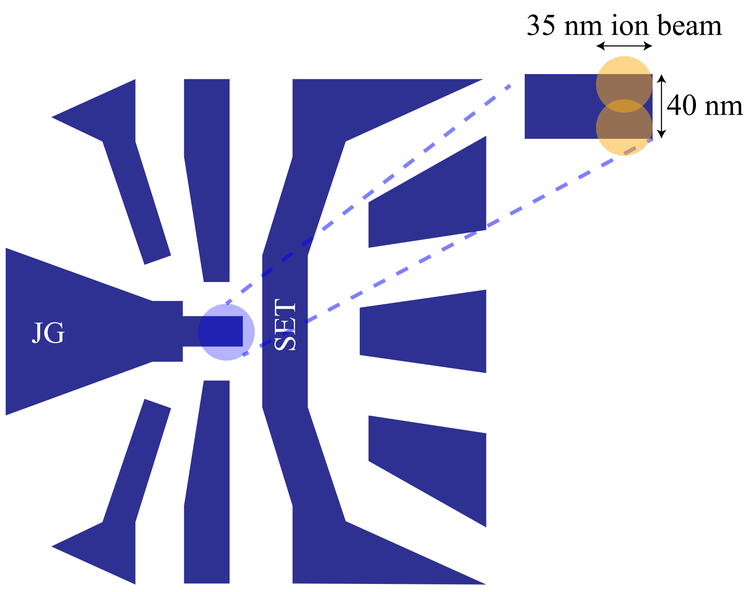
Transport measurements at 2K in the **device with a counted number of implants show regular coulomb blockade and offsets**.



Experimentally determined capacitances of the quantum dot to various gates agree with simulations proving that an electrostatically defined ot can be formed in these integrated devices.

CONCLUSIONS AND OUTLOOK

- Diode detectors with single ion detection sensitivity have been integrated next to functional single electron transistors
- The technique we have developed using a focused ion beam and counting single ion implants can control both the number and the location of donors
- This control is necessary for future donor based spin qubit devices.



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