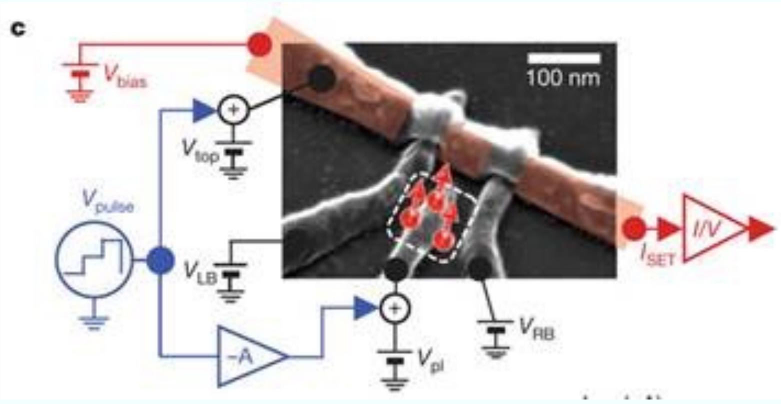
Single-shot readout of an electron spin in silicon

A Morello, JJ Pla, FA Zwanenburg, KW Chan, KY Tan, H Huebl, M Möttönen, CD Nugroho, C Yang, JA van Donkelaar, ADC Alves, DN Jamieson, CC Escott, LCL Hollenberg, RG Clark & AS Dzurak
Nature 467, 687 (2010)



Scanning electron micrograph of a device (the dashed square is where the P donors are implanted; the red shaded area represents the electron layer).

The size of silicon transistors used in microelectronic devices is shrinking to the level at which quantum effects become important. Although this presents a significant challenge for the further scaling of microprocessors, it provides the potential for radical innovations in the form of spin-based quantum computers2–4 and spintronic devices. An electron spin in silicon can represent a well-isolated quantum bit with long coherence times because of the weak spin–orbit coupling and the possibility of eliminating nuclear spins from the bulk crystal. However, the control of single electrons in silicon has proved challenging, and so far the observation and manipulation of a single spin has been impossible. Here we report the demonstration of single-shot, time-resolved readout of an electron spin in silicon.This has been performed in a device consisting of implanted phosphorus donors coupled to a metaloxide-semiconductor single-electron transistor—compatible with current microelectronic technology. We observed a spin lifetime of ~ 6 seconds at a magnetic field of 1.5 tesla, and achieved a spin readout fidelity better than 90 per cent. Highfidelity singleshot spin readout in silicon opens the way to the development of a new generation of quantum computing and spintronic devices, built using the most important material in the semiconductor industry.

LINK TO FULL PAPER (SUBSCRIBERS ONLY):
http://www.nature.com/nature/journal/v467/n7316/pdf/nature09392.pdf