Nuclear Polarization of Phosphorus Donors in Silicon MOSFETs at High Magnetic Fields

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Introduction

Spins of electrons and nuclei in silicon are promising quantum bit (qubit) candidates due to their long coherence times and the fabrication finesse of the silicon device industry [1]. One of the requirements for constructing a scalable quantum computer architecture is the ability to initialize the qubit [2]. Further, it is crucial that the qubits can be addressed and initialized locally. For this, electrical initialization schemes are preferable over optical excitation schemes. One approach is to use conduction electrons nearby the donor qubits to initialize the nuclear spin [3]. Previously we extended the study of spin dependent transport in donor-doped silicon MOSFETs to the higher magnetic field regime where the Zeeman splitting is much larger than the thermal energy. Further we showed electrically detected magnetic resonance (EDMR) measurements of silicon MOSFETs operating in the quantum hall regime for the first time [4]. Here we explore the time scales of the observed nuclear polarization process in MOSFETs.

Experimental

We performed spin dependent transport measurements in micron-scale phosphorus donor doped silicon MOSFETs by continuous wave EDMR in the magnetic field range of 8.5-12T with 239 and 336GHz microwave excitation. These measurements were performed with the heterodyne spectrometer in the EMR/EPR facility with custom-built sample holders. The experiments were carried out in the temperature range of 3-15K with the applied magnetic field in-plane of the gate-induced 2DEG of the MOSFETs.

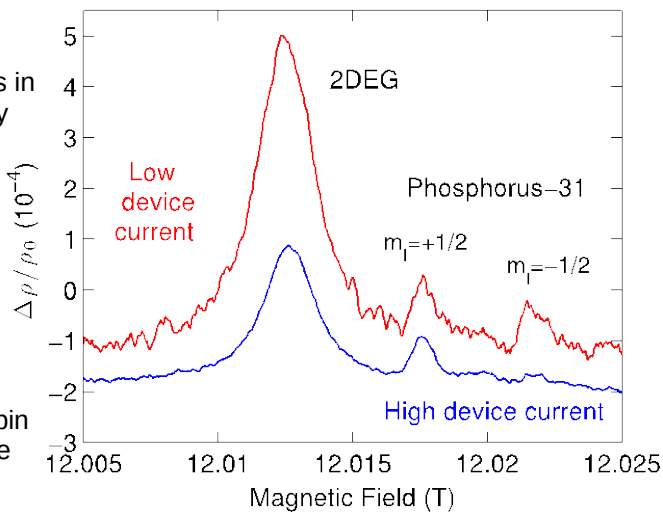

Figure 1: cw-EDMR signal of 28Si:P MOSFET

Results and Discussion

The effect of the conduction electrons on the nuclear spin distribution of phosphorus dopants in ^{28}Si-MOSFETs can be seen in **Figure 1**. A low device current (I=200nA) results in equally populated nuclear spin orientations. An increased device current (I=2uA) polarizes the nuclear spins into the m_I=+1/2 state. EDMR time traces recorded at the m_I=+1/2 resonance line at B=8.5T are shown in **Figure 2** and enable the measurement of the (de-) polarization time scales.

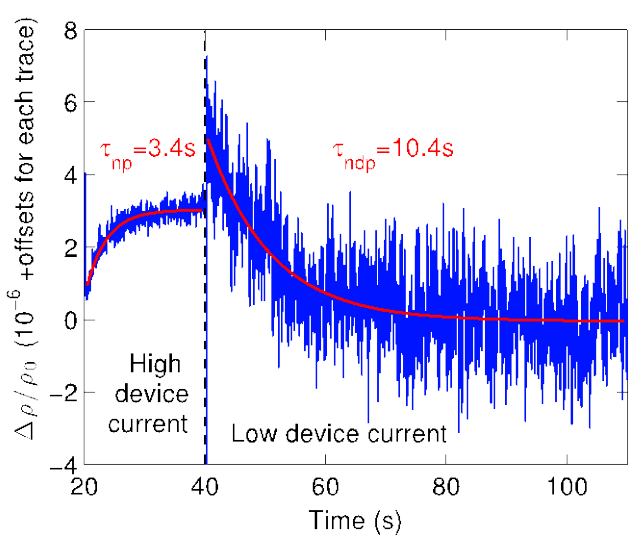

Figure 2: Time trace of m_I=+1/2 resonance line

Conclusions

We have demonstrated an all-electrical nuclear polarization mechanism in phosphorus-doped silicon MOSFETs with initialization times of a few seconds.

Acknowledgements

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References

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