Masters's Project

Cryogenic HBT amplifiers for Spin Qubit Readout

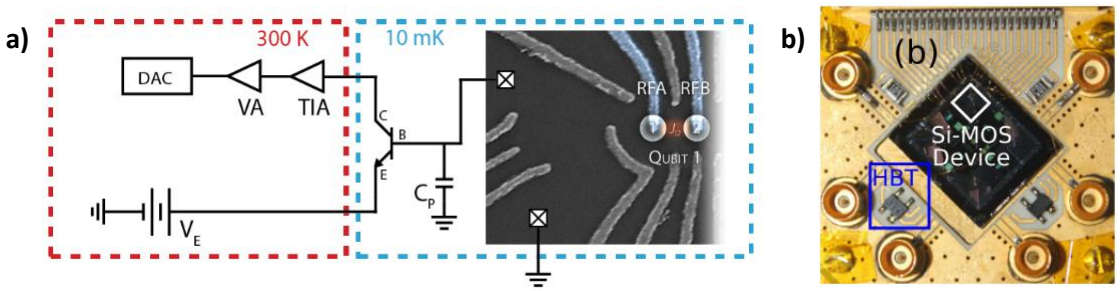

Fig. 1 (a) *Schematic of the readout circuit using a heterojunction bipolar transistor on the mixing chamber of a dilution refrigerator. The right side shows the layout of surface electrodes to confine single electrons within the semiconductor heterostructure in order to form quantum bits.* ***(b)*** *Picture of an HBT integrated next to a quantum chip. (Picture by Sandia National Laboratory,* **https://arxiv.org/abs/1901.04570***)*

Background

As semiconductor-based electron spin-qubits move from samples with small qubit numbers to large-scale devices, scalable control and readout methods will become increasingly important in the quest for quantum computation. Current generation spin qubits are usually read out using microwave reflectometry measurements, which - while offering fast read out times - require bulky room temperature hardware. This does not allow these methods to scale easily to the qubit numbers needed for large-scale quantum computation. However, recent experiments demonstrated that heterojunction bipolar transistors (HBTs) can be operated at mK temperatures in close proximity to the qubits and used for amplification and multiplexing of the readout signal. This would significantly reduce the hardware overhead for large-scale systems and therefore be an essential step for next generation semiconductor devices.

Your Task

Your task will be the measurement of an HBT amplifier connected to the sensing quantum dot on one of our qubit chips. These measurements include basic tune-up and noise performance analysis of the transistor in different bias regimes as well as tuning of a qubit next to the readout circuit. Further, you will analyse the back action of the transistor on the qubit using the relaxation rate T1. Additionally, you will measure and characterize HBTs produced by different manufactures and processes and evaluate them as alternatives for qubit readout.

This project will allow you to extend your knowledge of these topics, among other things:

- Theory of electron spin qubits and quantum computation
- Electronics at sub-Kelvin temperatures
- Theory and modelling of transistor at low temperatures
- Qubit tuning and readout methods

Furthermore, you will participate in group seminars and Journal Clubs to discuss cutting-edge developments in this area of research.

References

https://arxiv.org/abs/1901.04570

https://arxiv.org/abs/1509.08201

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