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Integration of Molecular Quantum Bits with Semiconductor Spintronics

Introduction

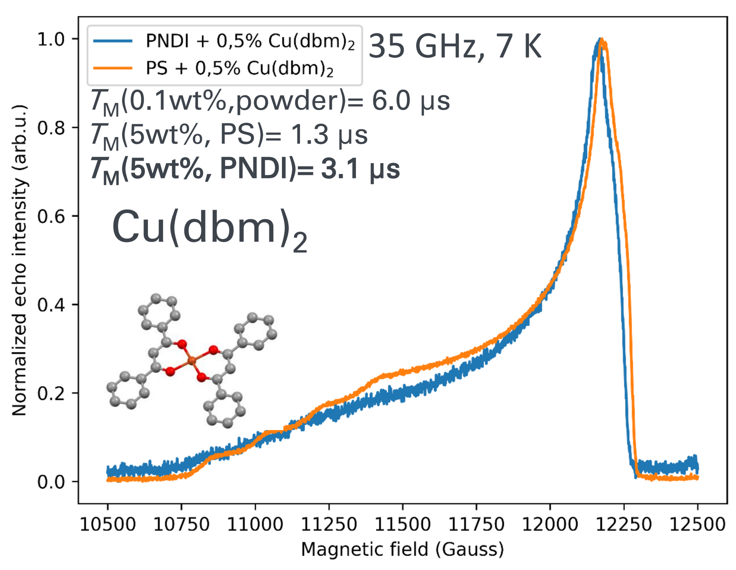
Molecular nanomagnets hold great promise for quantum computing, as they have been shown to exhibit coherence times (T_M) from tens of microseconds up to almost a millisecond. The molecular nature of these systems offers the possibility for extended chemical tailoring for higher coherence times or surface self-assembly. However, addressing of the molecular qubits in a usable device architecture is still an unsolved challenge.

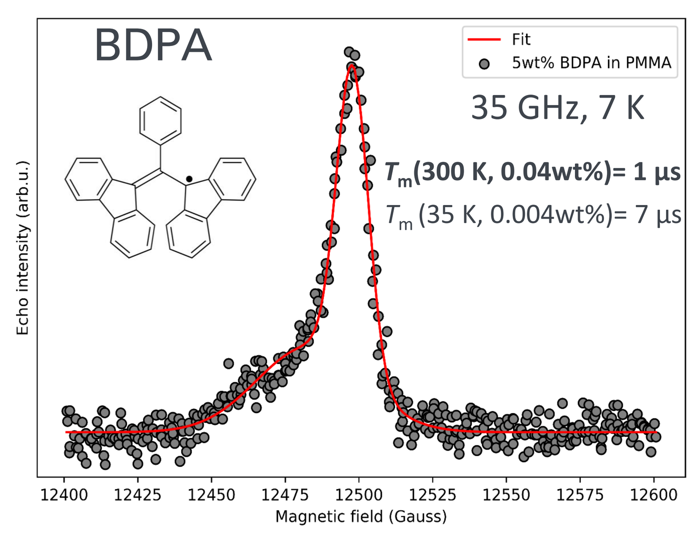
We will try to develop novel methods of electrical programming/readout of our qubits using dipolar interactions with mobile charge carriers in various systems.

Material Systems

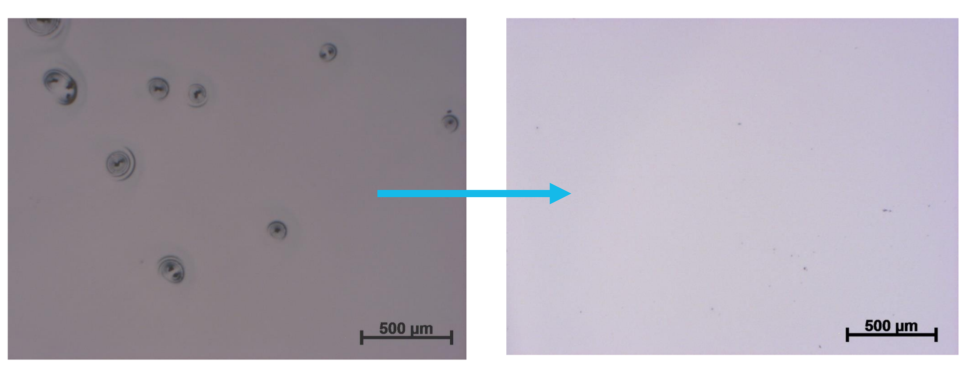
Qubit hybrid materials

We have successfully measured quantum coherence times of different molecular qubits in both insulating and conducting polymers using electron spin resonance (ESR).

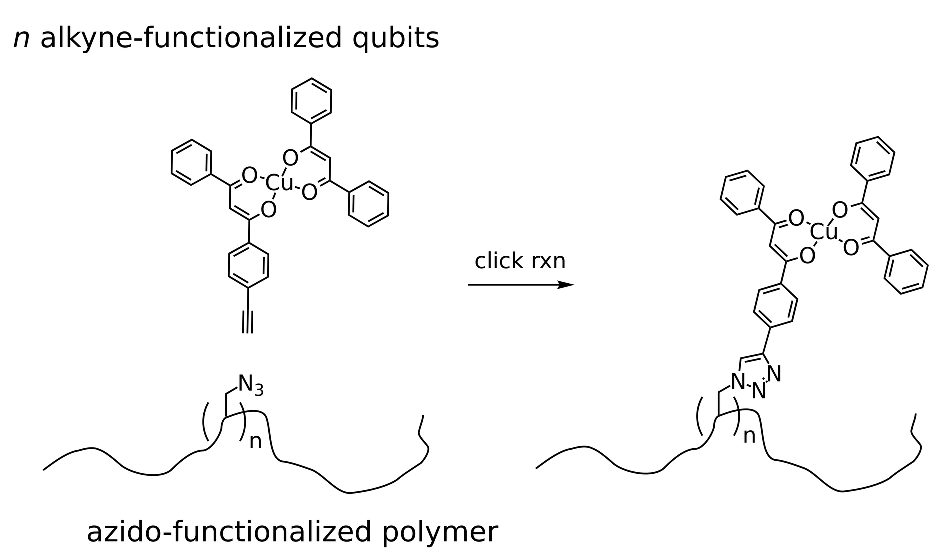




Next step is optimization of the polymer layer: from thick drop-casted layers with qubit aggregates to ordered thin films with fully dispersed qubits.



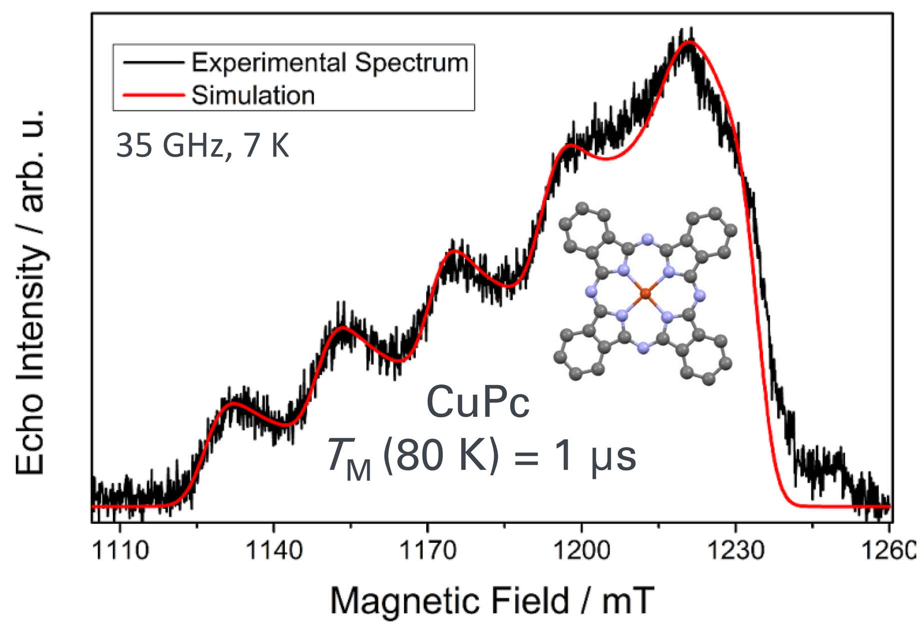
To achieve full qubit dispersion, we are developing a qubit/conducting polymer click reaction.



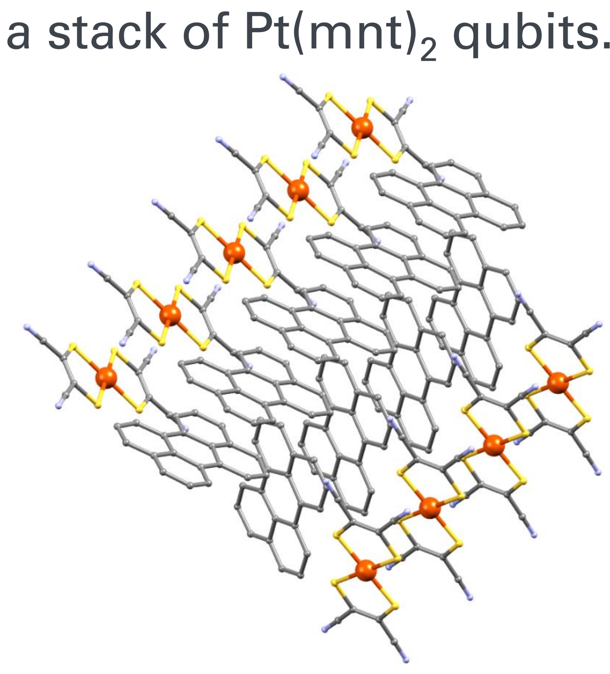
Intrinsically conducting/magnetic materials

We have started to investigate materials which already possess both mobile charge carriers and stationary quantum bits.

CuPc is a highly stable paramagnetic molecule, ideal for evaporation and is also a disordered semiconductor. After evaporation it prefers an edge-on configuration, as revealed by ESR.

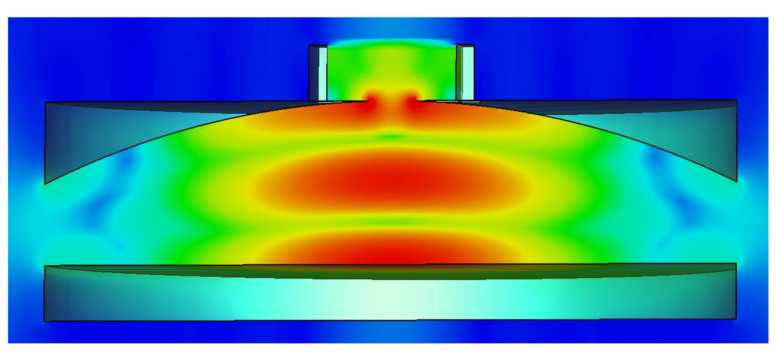


Another similar system is $(Per)_2Pt(mnt)_2$. This system forms however a molecular 1D conductor along a stack of $Pt(mnt)_2$ qubits.



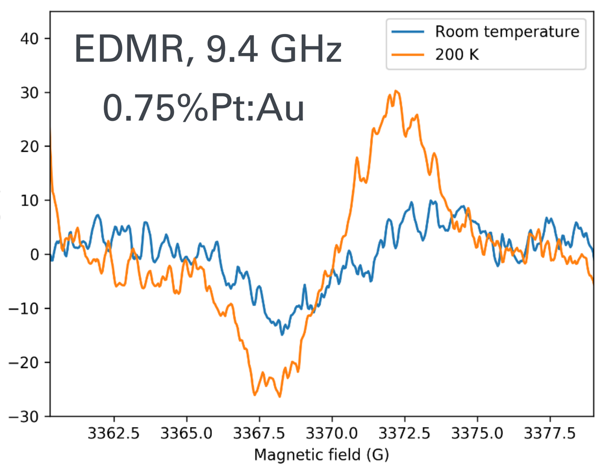
How to detect qubit/charge carrier coupling?

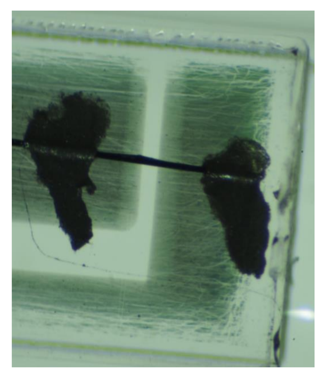
We will use pulsed ESR at 35 GHz in the presence of mobile charge carriers to look on the influence of the presence moving charges on the coherence times of qubits using a custom Fabry-Pérot resonator.



Electrically Detected Magnetic Resonance

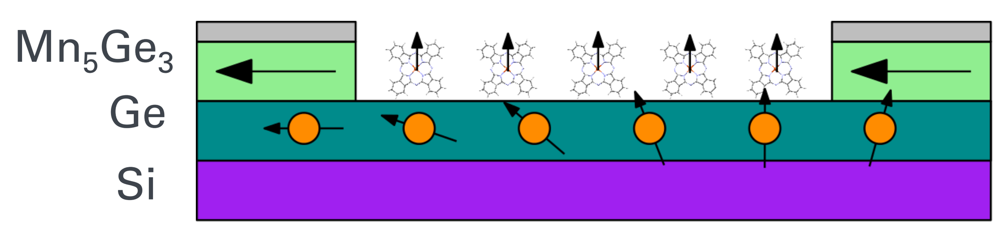
To investigate how do the qubits influence charge transport, we will use EDMR at 9.4 GHz. Using this spectroscopic method, we can directly study the interactions relevant for device development.





Spin-polarized charge carriers

Another exciting option is to use lateral spin valve geometry and study the dipolar coupling between spin polarized charge carriers and deposited qubits by observing the magnetoresistance. We have developed a facile way of creating ferromagnetic electrodes with atomically flat interfaces on Ge and observed spin-polarized transport in doped Ge. In the next step, we will deposit the molecular and perform low-temperature magneto-transport measurements.



Acknowledgments

The authors would like to acknowledge Bastian Kern from the Max Planck Institute for Solid State Research in Stuttgart for evaporation of CuPc molecules, prof. Almeida from University of Lisabon for perylene crystals, the Center for Integrated Quantum Science and Technology (IQ^{ST}) and the PETER project for funding.

IQ ST Integrated Quantum Science and Technology
PETER

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