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Scalable Electrically Read Diamond Spin Qubit Technology for Single Molecule Quantum Imagers



*Website:
<https://qmagine.univie.ac.at>
Coordination and contact:*

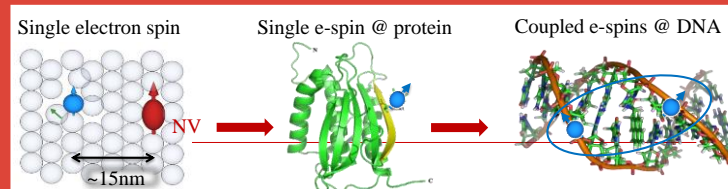
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Q –MAGINE goals

Establish technologies and techniques for quantum NMR at nanoscale using diamond NV qubit platform, aiming at diagnosing and imaging individual molecules



UHasselt

Developing photoelectric spin readout for electron and nuclear spins

Imec

Developing single molecular placement technologies

University Ulm:

Designing and realising advanced quantum protocols for improving S/N ratio and spectral resolution for chemical shift measurements

Wigner Centreum for Physics

Ab initio modeling of NV and group for IV-Vacancy qubits

University Viena

Developing quantum chips and quantum matrix addressing

IMO-IMOMEC

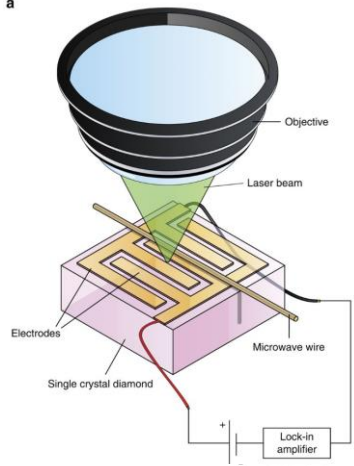
▶▶ UHASSELT imec

Krakow 20-21/ 10/2022



QUANTERA

a



UHasselt

M. Gulka, E. Bourgeois, M Nesladek

Basic techniqque

Photoelectrical readout of spin states

E. Bourgeois et al , Nature Comm. 2015

P. Siyushev et al , Science, 2019

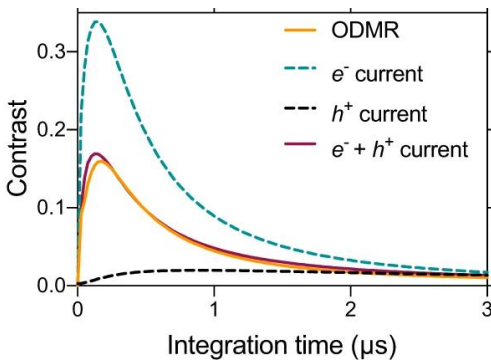
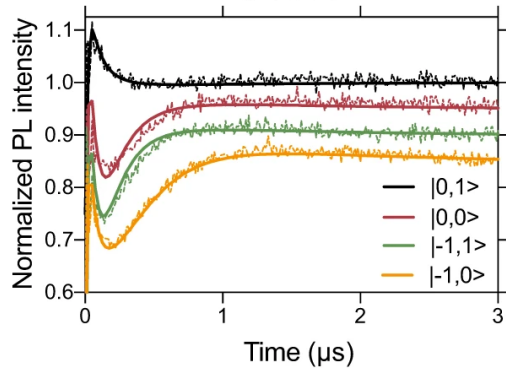


UVienna.

D. Wiritisch, M. Trupke

Wigner Centre for Physics

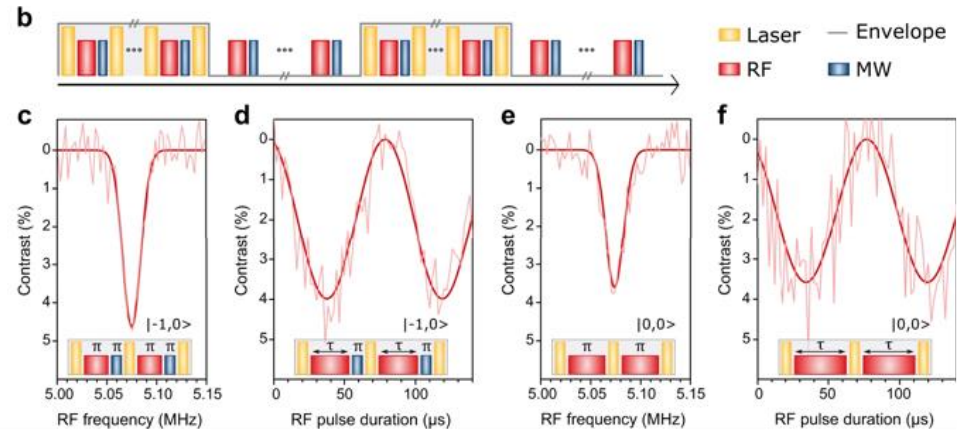
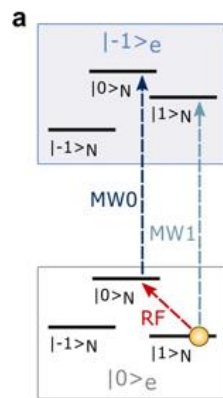
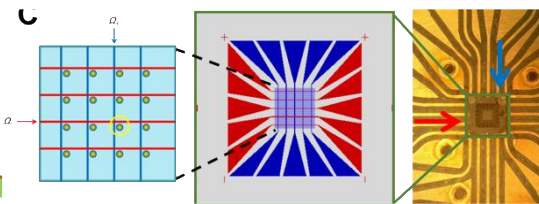
V. Ivady, A. Gali



Extended to

Detection of single Nuclear Spins

Current fidelity 99.97 % (QST)



M. Gulka et al, Nature Comm, 2021

Nuclear spin addressing

IMO-IMOMEC



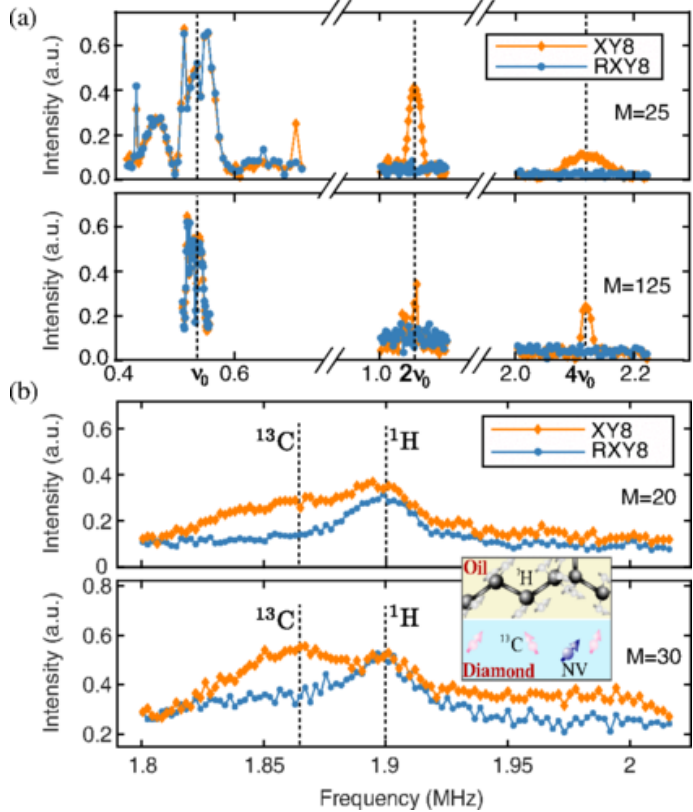
UULM

P. Siyushev, Zhen-Yu Wang, F. Jelezko, M. Plenio



Theoretical design and experimental realising q-protocols

Single molecule placement



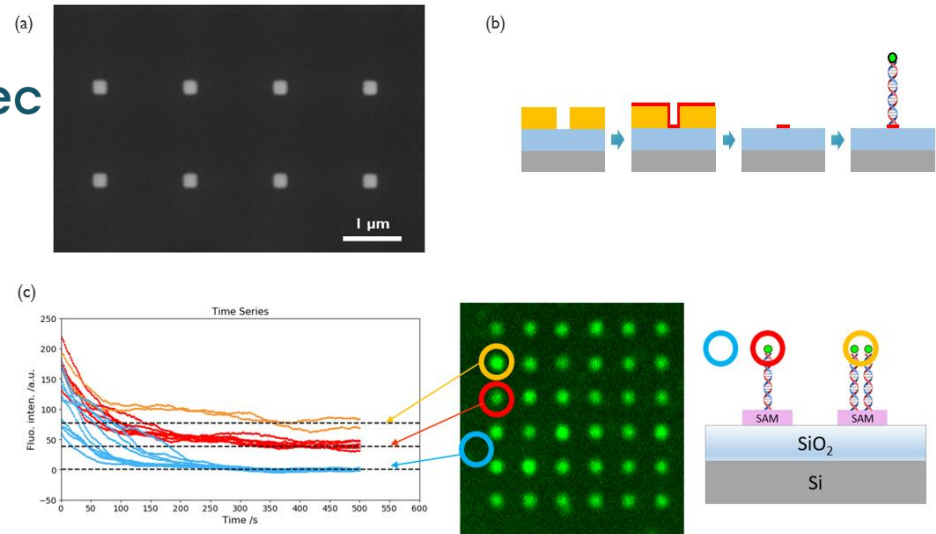
- a) Noise suppression
- b) Detection of proton spins using randomisation protocols

S. Schmitt et al, *Science* 356, 832–837 (2017)
 Zhen-Yu Wang, *PRL*, 24;122(20):200403 (2019)



Imec

K. Mertens, Karolien Jans, Seungkyu Ha



Single Molecule attachment. SEM of fabricated nanodot arrays. (b) Patterned self-assembled monolayer (SAM, red color). Desired biomolecules can be site-selectively attached to the patterned SAM (DNA) (c) Fluorescence measurement allows quantification of the number of biomolecules: zero (blue), one (red), or two molecules (yellow).

Q-Magine has successfully developed:

- **Electrical spin state readout** of NV centres used for detection of single nuclear spins in a close environment.
- **Integrated quantum chip** with established matrix addressing of the individual pixels
- **Protocols** allowing to increase the spectral resolution to sub-mHz range.
- **Single molecule attachment** and their deterministic placement
- **Further prospects:** Spectroscopical reading and addressing individual external spin carrying molecules (chemical shift)
- **Industrial collaborations:** Companies from Pharma research were interested in our project, leading to bilateral developments and contracts which are currently being pursued.

MAESTRO



Qmagine protocols and chip integration will be used for design of quantum processors