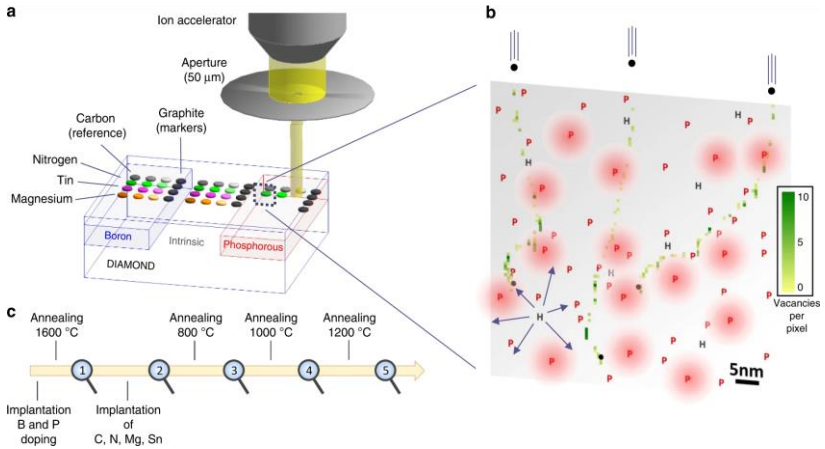
UHasselt — M. Nesladek
CiS — Mario Bähr
Université Sorbonne Paris Nord, CNRS — J. Achard
University Leipzig — J. Maijer
Saxon Q — M. Grundmann
Chimie ParisTech – PSL,CNRS — A. Tallaire
University of Ulm — F. Jelezko
Wigner Research Centre for Physics — A.Gali

MAESTRO

MASTERING TECHNOLOGIES for SCALABLE SPIN-BASED SOLID-STATE QUANTUM PROCESSORS

Abstract

MAESTRO proposes to develop solid-state qubit architectures for working at reasonably low or ambient conditions, as a compelling path towards industrially interesting medium scale quantum systems. The central aim of the proposal is to tackle the bottle neck issues of our technology for diamond processor hardware scalability, e.g., the deterministic engineering and fabrication of NV qubits with a high fabrication yield that will allow then to scale our technology to industrially relevant processes. MAESTRO will provide a quantum processor platform that can be further developed, in future, towards marketable industrial applications.



a Diamond sample with intrinsic, p-type and n-type areas (by implantation with [P] and [B]), and implanted additionally with carbon (as a reference) and nitrogen, tin, and magnesium to produce, NV, SnV and MgV centres **b** Illustration of the sample status after implantation **c** Time sequence of the different steps of the study. The magnifiers symbolise imaging spectroscopy

Concept of 2e x2e x 4n quantum with each NV electron spin (e) coupled to 4 nuclear spins (n)

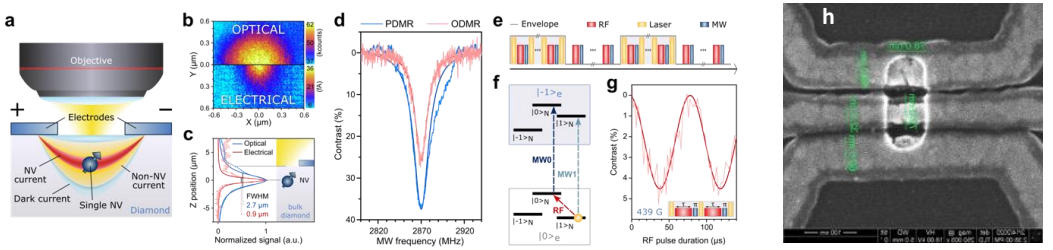
[1]T. Lühmann el al, Nature Comm, 10, 4956 (2019)
[2]F. Dolde et al, Nat. Phys., 9, 139–143, (2013)
[3]P. Siyushev P. et al , Science , 363(6428), 2019
[4]M. Gulka et al , Nature Comm., 12, 4421 (2021)

Aims:

(i) Optimisation of material technologies
(ii) Deterministic NV formation
(iii) Electrical readout of spin states
(iv) Device fabrication

WP1: Qubit fabrication
WP2: Device fabrication
WP3: Qubit control
WP4: Technology demonstrator and use case analysis

The recent results, established within this consortium, discovered the possibility of near-deterministic generation of solid-state-qubits[1], NV centres in diamond. Placing them at a distance of about 10-40 nm would allow for high-fidelity two-qubit gates based on magnetic dipole-dipole coupling[2]. The method of electrical readout of the spin, also discovered recently by the consortium members[3,4], allows for individual spin qubit readout, dealing with the major constrain of the diamond quantum hardware scalability. At the same time we explore novel diamond colour centres that can operate as effective spin qubits.



***a** Schematics for photoelectric readout of a single nuclear spin coupled to an electron spin. **b** Comparison between NV photoelectric and optical mapping. **c** High 2-photon ionisation depth resolution compared to optical resolution. **d** High spin contrast achieved for NV electron spin photoelectric detection. **e, f, g** 14N nuclear spin driving and photoelectric readout via entanglement to NV electron spin[4], **h** nanolithography engineered contacts on diamond serving for electrical spin readout.*

***Website:** http://uhasselt.be/maestro*
Coordination and contact
milos.nesladek@uhasselt.be