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Application of ion irradiation for quantum computing: Implantation of nitrogen containing molecules and sulfur for the realization of spin qubit registers in diamond working at room temperature

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The nitrogen vacancy (NV) center as spin defect in diamond is one of the only physical systems suitable for room temperature quantum computing [1], which might facilitate novel groundbreaking developments in the areas of e.g. drug research, energy harvesting or industrial process optimizations. For this, the electronic and nuclear spin of the negatively charged NV center and surrounding ^{13}C nuclear spins can be employed as qubit register [1]. Artificial creation of NV centers is possible by nitrogen ion implantation and subsequent annealing. Unfortunately, this process suffers from poor conversion yields of implanted nitrogen to NV centers of < 10% and charge state instabilities [2].

Employing the co-implantation of sulfur as donor and nitrogen containing species such as N, N_2 [3] or $C_5N_4H_n$ [4], we will show that the conversion yield can be drastically increased towards 90% enabling deterministic creation of NV centers [2] as prerequisite for the reliable fabrication of quantum registers. Additionally, the negative charge state is stabilized by the sulfur doping and coupled NV centers are realized for the application in large qubit register arrays. This patented technique lead to the development of the world' s first mobile quantum computer working at room temperature whose operation principle will be presented. The heart of the processor is a 4-qubit quantum register consisting of an NV center and two ^{13}C nuclear spins coupled to it. Universal quantum gate operations and especially native multi-qubit gates can be performed with high fidelity and quantum entanglement will be demonstrated. Using an intuitive user interface, general quantum algorithms can be run on the processor which calibrates itself automatically.

[1] Pezzagna and Meijer, Appl. Phys. Rev. **8**, 011308 (2021)
[2] Lühmann *et al.*, Nature Comm. **10**, 4956 (2019)
[3] Dolde *et al.*, Nature Physics **9**, 139 (2013)
[4] Haruyama *et al.*, Nature Comm. **10**, 2664 (2019)

Paper submission Plan

No

Best Presentation

No

Contribution track

ICABU WG4. Applications of Particle Beams

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