An integrated platform for the SiC-based Quantum Technologies from sensing to simulation

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Abstract: An integrated experimental and computational platform is presented aiming at the design and the realization of devices with quantum enhanced features where modelling supports the virtual expansion of the real functionalized materials, tests and protocols.

We present our progress toward the development of a complete platform aimed at enabling quantum (Q-) technologies (Q-ket) based on colour centres in SiC and, in general, other Wide Band Gap (WBG) materials and systems (see pictorial representation in figure with colour shadowing and references [1-5]). The platform considers a chain of process steps, which are sequentially characterized and designed with the final scope of realizing Q-devices (yellow shadow in figure) where control and electro-optical operational protocols are implemented (orange shadow in figure). Process and functional design are aided by the virtual realization (Q-TCAD) of time dependent atomistic material modifications (green shadow in figure) and quantum control protocols (red shadow in figure). First principles studies are dedicated to accurately study the fundamental interactions of known, less known and unknows active centres (blue shadow in figure). Examples of the results of this experimental and computational studies will be discussed for the case of bulk and near-surface vacancy type functionalization of Q-devices (from sensors to simulators).

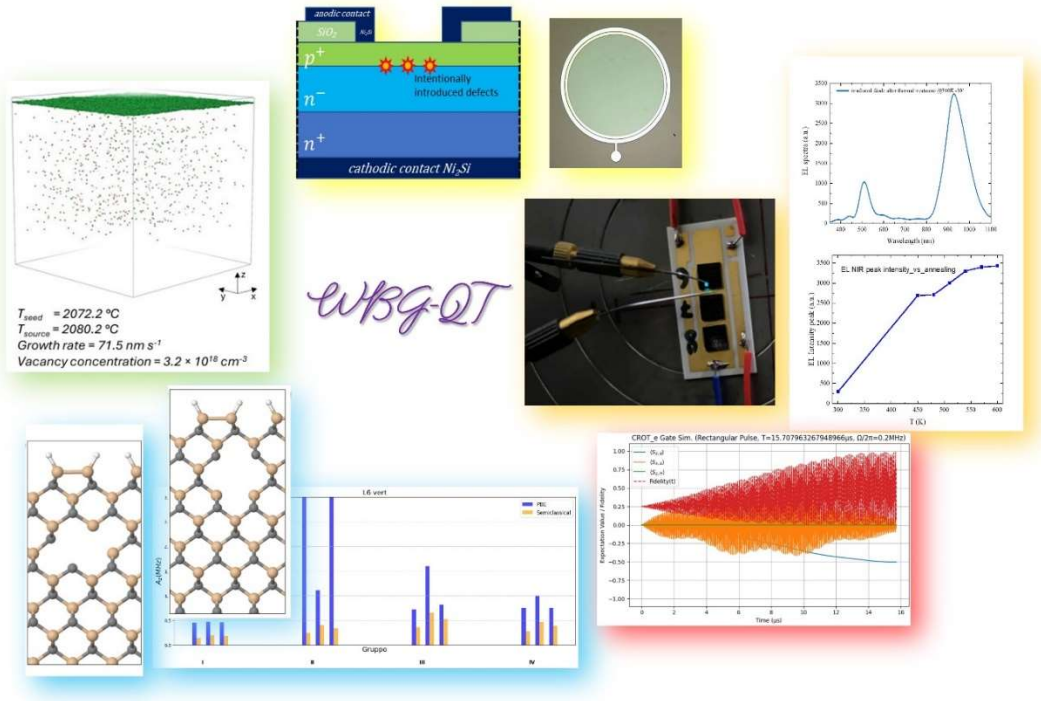

Figure Integrated methodologies for SiC, and in general Wide Band Gap, based quantum technologies: ab-initio study of active centres fundamental interactions (blue shadowing), atomistic process simulation of centres generation (green shadowing), device design functionalization, and fabrication (yellow shadowing), electro-optical characterization (orange shadowing), protocol-optimization with many qubit Hamiltonian models.

References

[1] Philip Kitson,Tobias Haug, Antonino La Magna, Oliver Morsch and Luigi Amico "Rydberg atomtronic devices" Physical Review 110, 043304 (2024), https://doi.org/10.1103/PhysRevA.110.043304, NQSTI acknowledgement

[2] Antonella Sciuto, Pietro P. Barbarino, Domenico Mello, Giuseppe D'Arrigo "Insight on defects mechanically introduced by nanoindentation in 4H-SiC p-n diode" Materials & Design 239, 112751 (2024) https://doi.org/10.1016/j.matdes.2024.112751. NQSTI acknowledgement

[3] Gaetano Calogero, Ioannis Deretzis, Giuseppe Fisicaro, Damiano Ricciarelli, Rosario Gaetano Viglione, Antonino La Magna Advanced Quantum Technologies, 8 e2500160 (2025), https://doi.org/10.1002/qute.202500160, NQSTI acknowledgement

[4] Rosario G. Viglione, G. Castorina, G. Calogero, G. Fisicaro, D. Ricciarelli, I. Deretzis and A. La Magna Physica Status Solidi B (accepted in press 2026) http://arxiv.org/abs/2511.09436 NQSTI acknowledgement

[5] Simona Boninelli, Gaetano Calogero, Ivana Di Bari, Giusepp D'Arrigo, Antonino La Magna, Antonella Sciuto "SiC color center for quantum sensing: a study on their luminescence properties" in preparation, NQSTI acknowledgement