Atomic Defects in Nanomaterials for Integrated Quantum Technologies

Quantum technologies – encompassing communication, computation, and sensing – rely heavily on the properties of quantum systems, including spins and photons, to encode, process, and transmit information. Atomic defects in nanomaterials, such as diamond nanocrystals and hexagonal boron nitride (hBN), represent promising platforms for these technologies. These defect centres, formed by irregularities in the crystal lattice, offer unparalleled advantages in compactness, scalability, and integrability, making them prime candidates for advancing quantum devices. However, the challenges posed by decoherence and external perturbations, which limit system performance, remain significant hurdles.

This PhD project aims to overcome these barriers by designing advanced nanophotonic and optophononic interfaces to enhance spin coherence and spin-photon coupling. By combining innovative material engineering, state-of-the-art nanofabrication, and cutting-edge measurement techniques, this project seeks to fully harness the potential of defect centres in nanomaterials for next-generation quantum technologies. The outcomes of this research have the potential to significantly improve quantum communication systems, quantum sensors, and quantum information processors, paving the way for scalable quantum devices.

This exciting project is a collaboration between Queen's University Belfast (QUB) and Trinity College Dublin, offering access to world-class facilities and interdisciplinary expertise. It also aligns with the objectives of Smart Nano NI, strengthening ties with industry leaders such as Seagate, Causeway Sensors, and Andor Technology, and bridging the gap between fundamental research and practical applications.

As a PhD researcher, you will have the opportunity to develop expertise in a range of advanced techniques, including:

- Nanophotonic design and nanofabrication to optimise quantum emitter coupling.
- Single-photon measurements and characterisation of spin-photon interactions.
- Low-temperature spectroscopy and advanced optical imaging methods.
- Prototyping quantum devices with potential applications in industry.

You will join the Centre for Quantum Materials & Technologies at the QUB School of Mathematics and Physics, where cutting-edge quantum and nanoscale optics research is conducted. This project offers a unique opportunity to contribute to the future of quantum science while working across interdisciplinary fields including photonics, materials science, and quantum optics.

How to apply:
For informal inquiries, please contact Dr. Hamidreza Siampour (h.siampour@qub.ac.uk) and Prof. Robert Bowman (r.m.bowman@qub.ac.uk).

References

1. Siampour, H. et al. *Light: Science & Applications* **7**, 61 (2018).
2. Siampour, H. et al. *npj Quantum Information* **9**, 15 (2023).
3. Stern, H. et al. *Nature Materials* ***23***, 1379-1385 (2024).
4. Snow, K. et al. *Frontiers in Physics* **12**, 1475071 (2024).