

Diamond-based Quantum Sensors for Next Generation NMR Applications

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Defence industries have been at the forefront of chemical sensor development over the past decade, with the successful deployment of techniques based on mass spectrometry, FTIR spectroscopy, and Flame photometry point detectors, to name a few. Nuclear magnetic resonance (NMR) spectroscopy, on the other hand, is the gold standard of chemical characterisation and quantification in high-end research and quality control laboratories. No other analytical technique has the equivalent specificity to quantify the content, purity, and molecular structures underpinning a given chemical sample. Yet this powerful and ubiquitous technique is not available to in-field operators needing to identify short-lived, highly toxic, or explosive samples.

This is primarily due to high capital and running costs, the use of liquid helium for cooling magnets, and limitations in sample presentation. Attempts to circumvent these requirements for the realisation of portable NMR systems have been met with significant compromises in sensitivity, specificity, and minimum required sample volumes. Given the maturity of the technology, additional optimisation of equipment engineering is only leading to minor, iterative improvements, necessitating a novel approach to revolutionise the field.

The recent advent of quantum sensors promises to revolutionise the NMR chemical detection industry by dramatically reducing the size, cost, maintenance, and complexity of its instrumentation without compromising on chemical sensitivity and specificity. This is made possible thanks to crystallographic nitrogen-vacancy defects which can be engineered into synthetic diamonds to act as quantum sensors, capable of detecting NMR signals from molecular nuclei present in minute traces of chemicals applied to the diamond surface [1-5]. In this talk, I will give an overview of our progress in developing a portable NV-diamond based NMR spectrometer, including benchmarking of detection limits and identification of chemical residues of interest against conventional techniques. Finally, I will discuss the broader future opportunities presented by this technology in health and environmental analytical applications.

[1] Hall, L.T. et al., *Nature Communications* **7** (2016).

[2] Simpson, D.A. et al. *Nature Communications* **8** (2017).

[3] Smits, J. et al. *Science Advances* **5** (2019).

[4] Glenn, D.R. et al. *Nature* **555**, (2018).

[5] Schmitt, S. et al. *Science* **356**, 832 (2017).