Optically addressable spin defects in hexagonal Boron Nitride

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Optically addressable spin defects in wide band gap materials are highly sought after to the realization of quantum devices and scalable quantum communication technologies. Tremendous effort has been made to engineer, characterize and control spin defects in solid-state host such as nitrogen vacancy centers in diamond [1] and di-vacancy in silicon carbide [2]. The undisputed success of these systems—marked by the ability to initialize, manipulate and optically read out individual spins with long coherence times.

In this regard, two dimensional materials such as Hexagonal boron nitride (hBN) are emerging an alternative platform for realization of quantum devices due to their unique pick and place fabrication methodology. Hexagonal boron nitride has been employed, for instance, in the realization of photonic crystal cavities and optomechanical resonators, as well as in the study of fundamental phenomena involving the subwavelength propagation of phonon-polaritons. The material is also host to atom-like quantum emitters. They are widely utilized due to desirable properties such as high brightness and stability, large stark-shift tuning, photo-physics compatible to super resolution imaging, and addressable spin-dependent optical emission [3]—which is the focus of this work.

Here we demonstrate the controlled engineering of boron vacancy (V_B^-) defects that exhibit optically detected magnetic resonance (ODMR), at room temperature [4]. We build upon the recent observation of ODMR in neutron irradiated bulk hBN crystals and demonstrate a versatile method for creating the V_B^- centers responsible for the ODMR signal based on focused ion beam (FIB) technique. We further demonstrate hybrid coupling of these spin defects into plasmonic gap cavity and whispering gallery modes of suspended ring resonators made from Titanium oxide [5,6]. Our results mark an important step towards the controlled generation of optically-active hBN color centers with spin-dependent photon-emission.

[1] J. H. Bodey, et al, npj Quantum Information, 95 (2019).

[2] S. J. Whiteley, et al, Nature Physics, 490-495 (2019).

[3] A. Gottscholl, et al, Nature Materials, 540–545 (2020).

[4] M. Kianinia, et al, ACS photonics, 2147–2152 (2020).

[5] N. Mendelson, et al, Advanced Materials, 2106046 (2022).

[6] M. Nonahal, M., et al, arXiv preprint arXiv:2205.04031 (2022).