Preferential coupling of NV nanodiamond to doped fibre and spliced SMF

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Diamond nanoparticles containing nitrogen-vacancy (NV) centres have attracted significant attention due to their ability for magnetic field sensing at room temperature. By incorporating these nanodiamond particles within optical fibres a hybrid platform can be developed [1] with the potential to realize magnetic field sensing with an optical readout over long distances and also the possibility to combine with commercially available fibres. To model this hybrid platform, we have considered the nanodiamond particles (containing NV centres) as dipole emitters and investigated the preferential coupling of these dipoles into the guided modes of a step-index fibre. Specifically, we have investigated the coupling of different dipole orientations into different guided modes as a function of (i) core/clad index contrast, (ii) core diameter, and (iii) radial position of the NV emitters within the core [2]. A schematic of the different coupling scenarios is shown in Fig. (a) – (c). To further explore the possibility of long-distance magnetic field sensing, we have also modelled the coupling efficiency of splicing diamond-doped fibres (sensing fibre) to commercial SMF-28e optical fibres. Using these models, we have investigated two coupling steps: i) fluorescence from NV nanodiamond to different modes of a step-index F2/LLF1 fibre (Fig.1 a-c), and ii) fibre modes coupling from an F2/LLF1 fibre to an SMF-28e fibre at the splicing point (Fig.1 d). Using overlap integral, simulation results show that 93% of LP01 and 34% of LP11 powers in F2/LLF1 fibre can be coupled into the SMF-28e fibre.

[1] D. Bai, M. H. Huynh, D. A. Simpson, P. Reineck, S. A. Vahid, A. D. Greentree, S. Foster, H. Ebendorff-Heidepriem, and B. C. Gibson, Fluorescent diamond microparticle doped glass fiber for magnetic field sensing, APL Materials 8, 081102 (2020).

[2] S. Li, D. Bai, M. Capelli, Q. Sun, S. Afshar V., D. A. Simpson, S. Foster, H. Ebendorff-Heidepriem, B. C. Gibson, and A. D. Greentree, Preferential coupling of diamond NV centres in step-index fibres, *Optics Express*, Vol. 29, Issue 10, pp. 14425-14437 (2021)

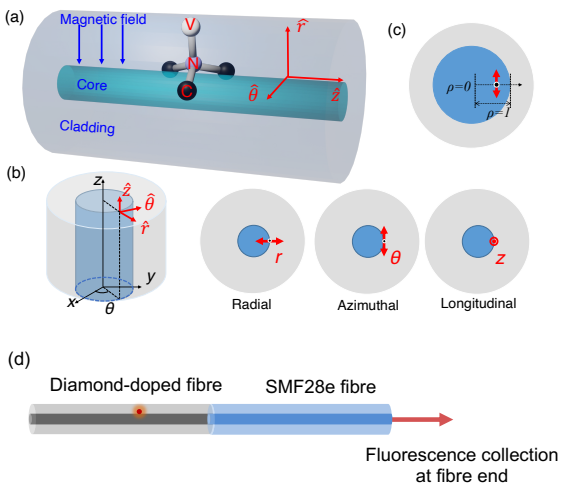

Fig.1 Schematic of the different coupling scenarios in diamond-doped fibre and spliced SMF fibre