Spin Transfer Using Chiral and Purcell-Enhanced Quantum Dots Embedded in a Glide-Plane Photonic Crystal Waveguide

Xuchao Chen[1*], Savvas Germanis[1], Hamidreza Siampour[1,2], René Dost[1], Dominic J. Hallett[1], Edmund Clarke[3], Pallavi K. Patil[3], Maurice S. Skolnick[1] and A. Mark Fox[1]

1. *Department of Physics and Astronomy, University of Sheffield, Sheffield S3 7RH, UK*
2. *Centre for Quantum Materials and Technologies, School of Mathematics and Physics, Queen's University Belfast, Belfast BT7 1NN, UK.*
3. *EPSRC National Epitaxy Facility, Department of Electronic and Electrical Engineering, University of Sheffield, Sheffield S1 3JD, UK.*

*xchen154@sheffield.ac.uk

The strong interaction between the charge carrier spin of a quantum dot (QD) exciton and photons enables a scalable, photon-mediated quantum spin network [1]. Via a specially designed spin-photon interface, the QD spin could be entangled with the propagation direction of the emitted photon, taking advantage of the chiral light-matter interaction [2, 3]. Here we present our study on a GaAs glide-plane photonic crystal waveguide (GPW) with embedded InAs QD emitters, where strong Purcell enhancement and high chirality criteria are satisfied for a single QD. Preliminary result shows a near-unity chiral contrast in the transmission geometry Fig.1(b), indicating a polarisation-dependent spin transfer between a QD and the waveguide mode. Additionally, the directional coupling gives rise to a non-linear single-photon phase shift, and a maximum phase shift of π could be achieved when the QD is chiral and perfectly coupled to the waveguide. This marks the basis of scalable implementations for a quantum phase gate and other on-chip spin-photonics based on chiral quantum optics [4]. Furthermore, the photonic devices are optimized for better transmission by introducing partially etched grating couplers and high-efficiency mode adaptors, with the aid of inverse design techniques.

(a) (b)

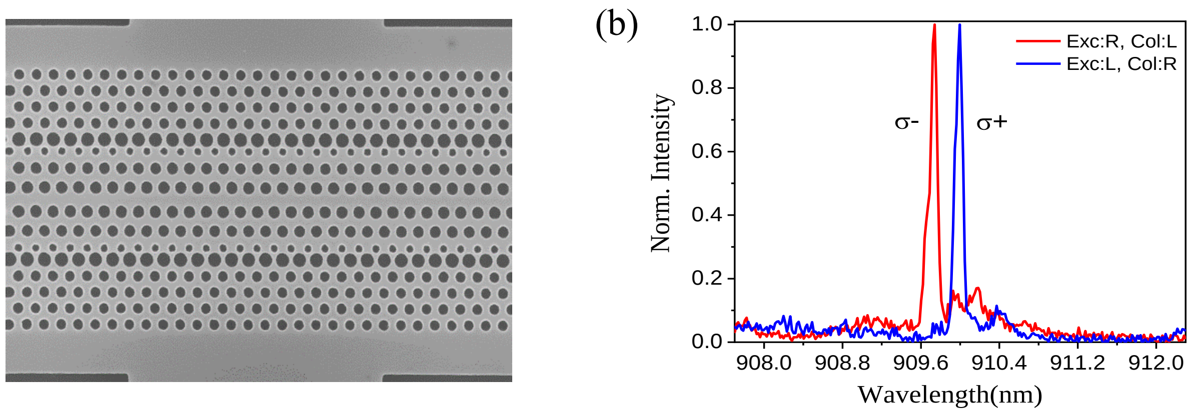

Fig.1.(a): SEM image of the single-mode glide-plane waveguide. (b): Photoluminescence spectra of the emission from a quantum dot exciton driven by a quasi-resonant CW laser (p-shell excitation) under +3T magnetic field in Faraday geometry. The experiment is done by exciting the QD from one out-coupler and collecting the PL signal from the other.

References :

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