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Proceedings Paper:
Fox, A.M. orcid.org/0000-0002-9025-2441 (2018) On-chip quantum photonics using integrated quantum dot emitters. In: 2018 20th International Conference on Transparent Optical Networks (ICTON). 2018 20th International Conference on Transparent Optical Networks (ICTON), 01-05 Jul 2018, Bucharest, Romania. IEEE . ISBN 978-1-5386-6605-0

https://doi.org/10.1109/icton.2018.8474029

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On-chip quantum photonics using integrated quantum dot emitters

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On-chip quantum photonics relies on the integration of efficient single-photon sources with advanced quantum-optical circuits. In this presentation, I will review progress at the University of Sheffield on a chip-compatible III-V semiconductor platform in which InGaAs quantum-dot (QD) single-photon emitters are integrated into GaAs photonic circuits. The presentation will have two parts. I will first discuss progress towards the generation of highly coherent indistinguishable photons by using the Purcell effect to enhance the radiative decay rate for an InGaAs QD coupled to an H1 photonic crystal nano-cavity [1]. Under resonant π-pulse excitation, an on-chip, on-demand single-photon source with a radiative lifetime of 22.6ps has been demonstrated that exhibits high purity and indistinguishability without spectral filtering. In a related experiment on a dot coupled to a photonic crystal waveguide, a resonant transmission dip of 40% has been measured, indicting very high coupling to the waveguide mode and low decoherence [2]. In the second part of the presentation, I will discuss chiral coupling between QDs and nano-photonic waveguides in which both chiral emission and exciton spin initialization has been demonstrated [3,4]. In the most recent work, non-reciprocal transmission has been measured, and explained by a model that incorporates realistic parameters for the dot [5]. These results rely on the precise positioning of dot within the nano-photonic structure, and lay the foundations for developing on-chip spin networks with spin qubits localized in different QDs.

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