Silicon photonics with T centre spin-photon devices

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Silicon is an ideal platform for commercial quantum technologies: it unites advanced integrated photonics and microelectronics, as well as hosting record-setting long-lived spin qubits. In this talk I will present advances towards an on-chip spin-network with the T centre, a spin-photon colour centre native to silicon that emits into an advantageous optical telecommunications band. Earlier studies demonstrated that the T centre features long-coherence electron and nuclear spin qubits [1] and may be isolated singly in integrated devices for confocal microscopy [2]. Here I present the first waveguide-coupled T centre devices. First, we characterize the spin and optical performance of ensembles implanted in single-mode waveguides. The homogeneous linewidth we measure, $30(10)$ MHz, is an order of magnitude improvement over earlier devices [2]. Second, single centres are measured in waveguide-coupled nanophotonic cavities. Lifetime measurements indicate substantial Purcell enhancement of the optical transitions. Additional spectroscopy of ensembles in isotopically enriched ^{28}Si illustrates how networked devices may be operated. These integrated spin-photon devices are manufactured on a commercial silicon photonic platform boasting low loss passive and active components, optical switches, high efficiency coupling to industry-standard telecom fibre, and near-unit efficiency single photon detectors. These elements may be assembled to create a completely on-chip spin-photon network that readily interfaces with optical fibres for long-range communication over the quantum internet.

[1] L. Bergeron et al., Silicon-integrated telecommunications photon-spin interface, *PRX Quantum*, **1(2)**, 20301 (2020).

[2] D. B. Higginbottom et al., Optical observation of single spins in silicon, *Nature*, **607**, 266-270 (2022).