Electrically Injected T Centre Emission

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Silicon colour centres are emerging candidates for quantum technologies that can be readily integrated with silicon-based photonic and electronic devices using existing commercial fabrication processes. The T centre is of particular interest for quantum technologies as it is a spin-photon interface possessing long-lived electronic and nuclear spins, operating in the low-loss telecommunications O-band [1]. It has also been proven to integrate with photonic devices on commercial silicon-on-insulator wafers [2, 3]. Further integration of the T centre with electronic devices is a promising route for developing electrically injected on-chip light sources, single photon sources, as well as approaches for spin–charge readout.

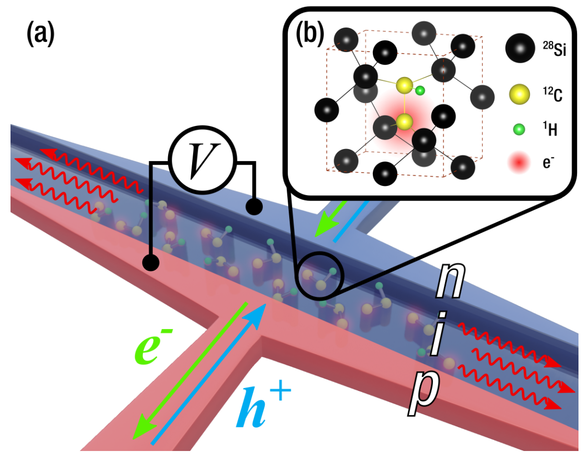

Fig. 1. (a) Schematic of an LED device with integrated waveguide and *p-i-n* junction for electrical T centre excitation. The applied bias injects electrons and holes, which pair to form free excitons in the intrinsic region containing the T centre ensemble. The T centres capture the free excitons which, with some probability, radiatively recombine with the emitted light coupling into the waveguide mode. (b) Structure of the T centre.

Electronic devices, such as diodes, can complement the optical interface of silicon colour centres, enabling additional techniques to control them and to probe their electronic properties [4]. Using diodes to create regions of tunable Fermi level and performing spectroscopy of T centres in these regions can shed light on its electronic structure and possible charge states, a topic that has been studied using density functional theory but has not yet been observed experimentally [5]. Combined optical and electronic control of T centres also requires designing devices that balance the requirements of the electrical interface with optical performance.

In this work we study electrical integration of T centres with lateral diodes for electrically injected emission. We perform confocal spectroscopic studies of bulk ensembles of T centres in lateral diodes to characterize their optical behaviour under varying Fermi levels and study T centre electroluminescence. We design devices that combine waveguide-integrated T centre ensembles with lateral diodes for electrically injected on-chip light-emitting diodes (LEDs) operating in the telecommunications O-band. Integrating these lateral diodes with cavity-coupled T centre devices we also investigate their potential as an electrically injected single-photon source.

References

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