Optical access of Er in Si with 0.5 ms electron spin coherence times

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Rare-earth ions in solid-state hosts exhibit low homogeneous broadening and long spin coherence at cryogenic temperatures, thus making them a promising candidate for optical-spin interfaces to achieve long-distance spin-spin coupling. Here, we present the electron spin properties of Er ensembles in Si accessed via resonant photoluminescence excitation. Samples were positioned directly on top of dedicatedly fabricated superconducting single photon detectors and resonantly excited using fiber optics [1]. We investigated natural and nuclear-spin-free ^{28}Si samples at Er densities of 10^{16} cm^{-3} implanted using ion beam. We extracted two sites at present in both nominally O free and 10^{17} cm^{-3} O doped samples in natural Si. The measured lifetime of the electron spin in the optical ground state was as long as 30 seconds at a magnetic field of 60 mT and a temperature of 20 mK. By introducing a wire antenna, we observed Rabi oscillations of over 1 MHz in both the natural Si and ^{28}Si samples. The free induction decay and coherence time of the electron spins in the ^{28}Si sample were investigated, leading to a T_2^* of 50 μs and a $T_{2,\mathrm{Hahn}}$ of 0.5 ms. Narrow optical linewidths and long spin lifetimes show that Er in Si is a promising candidate for future quantum information processing applications.

[1] I.R. Berkman, arXiv:2108.07090 (2021).