On-chip micromagnet for spin qubit architecture: magnetic characterization and integration

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Long-range spin-qubit interactions can be achieved via microwave cavities. Recent work [1] demonstrated coherent coupling between distant semiconductor spin qubits with 83% fidelity. Enhancing this fidelity requires reducing decoherence and increasing spin-cavity coupling.
By forming the dots in a suspended carbon nanotube, the coupling of the electron to the environment can be reduced [2].
An optimized shape of micro-magnet is developed [3] to enhance the electric control of the electronic spin through a microwave cavity. We combine thin-film magnetic characterization and localized measurements of the stray field of a micro-magnet with a NV center microscope and we successfully align our experimental findings with micromagnetic simulations for different magnetic materials. We predict a maximal antisymmetric field on each dot of ±100 mT. While our micro-magnet design is tailored for optimizing spin-orbit coupling, these characterization results also provide insights for other micro-magnet-based spin qubit architecture [4].
The resulting micromagnet design is integrated in a system composed of a suspended carbon nanotube and a magnetic field resilient high-impedance resonator [5]. Toward an improved spin-qubit resonator coupling, we measure an electron-resonator coupling of 165±20 MHz.

References

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Figures

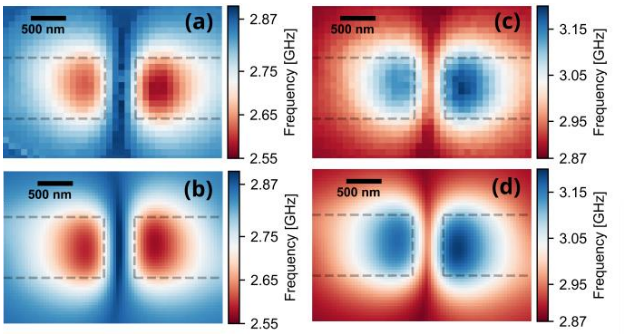

Figure 1: Magnetic characterization with a NV-center microscope. Spatial distributions of the resonance frequencies of a NV center located 500 nm above a Co magnet. Magnet boundary in dashed line. (a,c) f_{min} and f_{max} data. (c,d) f_{min} and f_{max} from the micromagnetic model.

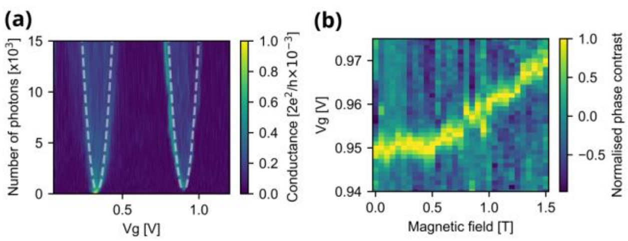

Figure 2: Quantum dot coupling to a magnetic field resilient high-impedance resonator. (a) Electron-photon coupling calibration by Coulomb peak power dependence measurement. Power broadening fit [6] (dashed lines). Fitted electron-photon coupling of 165±20 MHz. (b) Spectroscopy up to 1.5T of an electron state by measuring the cavity phase contrast as a function of magnetic field and gate voltage.