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# (G*) POS-F47 – Microwave resonators for global control of electron spins qubits

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Electron spins confined to quantum dots are a promising platform for scalable quantum computation. A necessary component of such a quantum processor is a microwave magnetic field ($B_1$) that implements single-qubit gate operations via electron spin resonance. A common method for generating a $B_1$ field is to place a micro-stripline close to the device. A second method is to place a micromagnet near the device and apply local voltage pulses to induce electric dipole spin resonance. Both methods involve elements that are bulky (> 1 µm) compared to the scale of an individual quantum dot (˜60 nm), and are placed on the surface of the chip, taking up valuable space and preventing scalable, dense packing of qubits. Furthermore, the $B_1$ produced by both methods is local, limiting single-qubit rotations to only a few quantum dots per micro-stripline or micromagnet.

We have investigated a centimeter-scale bowtie-shaped microwave resonator design that produces a global $B_1$ field with minimal electric field over a relatively large area (˜$mm^2$), which could enable single-qubit rotations for thousands of qubits. The design ensures that the magnetic field is maximal near the center of the resonator, whereas the electric field is expelled towards the edges of the resonator. A minimal electric field in the active area is necessary to prevent photon-assisted tunneling of the confined electrons. The resonator can be vertically integrated above the quantum device layer, removing the need for microwave interconnects or bulky components in the device layer. Individual qubits can be tuned in and out of resonance with this global $B_1$ field using the Stark effect, wherein the electronic $g$-factor shifts slightly as a function of applied electric field. Coupling an external microwave source to the resonator is achieved by an excitation stripline on the opposite side of a dielectric substrate. The resonator and stripline dimensions are optimized for operation at ˜15 GHz, corresponding to a DC magnetic field of 0.53 T for a $g = 2$ electron spin. At this field and a temperature of 100 mK, the spin qubit is initialized by relaxing into its ground state with a probability of 99.9 %. Our experimental implementation of lateral quantum dots in silicon will be discussed, along with progress in testing and integrating the global $B_1$ field resonator.

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