Photoinitialization of quantum dots in undoped GaAs

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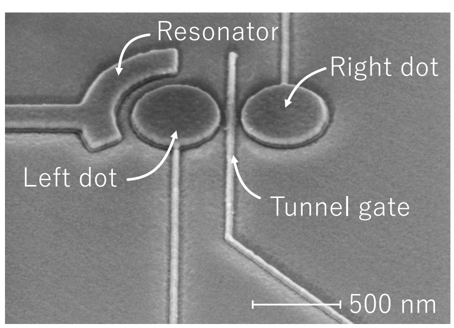
Scaling up gate-defined quantum dot systems is hampered by the rapid growth in the number of control gates. To tackle this challenge, we developed a novel scheme, in which the quantum dots are created from optically generated charges trapped beneath accumulation gates.

By shining an above-the-gap laser light onto an undoped GaAs substrate, we demonstrate that it is possible to create and separate electron-hole pairs to form quantum dots with one of the two polarities. By pairing this technique with a superconducting coplanar waveguide resonator for the charge readout[1, 2, 3], we achieve a working many-charge double quantum dot device with controllable interdot charge exchange. The device, comprised of only two plunger gates and one tunnel coupling gate, shows that the initialization of quantum dots does not require reservoirs, source/drain bias, ohmic contacts, or doping. Therefore, the number of gates can be reduced and the fabrication process can be simplified. Moreover, this new method can be applied to a wide range of semiconductor quantum dot systems.

Such a hybrid device is the first step towards a more scalable design for quantum dot arrays. It is also a good starting point for quantum transducing thanks to the optical–matter–microwave interaction[4].

a)



b)

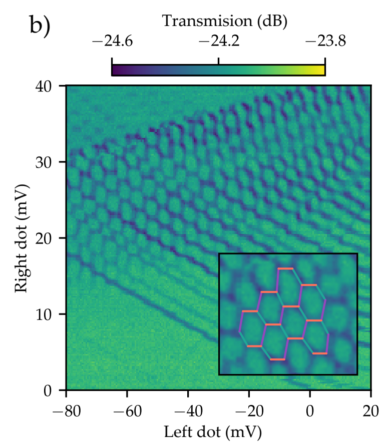


Fig. 1. a) Scanning electron microscopy (SEM) image of the gate layout for the double quantum dot device. The left and right plunger gates are separated by a tunnel gate. The left dot is also capacitively coupled to the resonator through an extension of the central conductor of the resonator, labeled as "resonator" on the image. b) Stability diagram for the double quantum dot device. Vertical and horizontal axes represent respectively the right and left gate potential. The color represents the transmission through the resonator. The inset identifies the three different types of transitions observed.

References

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