Electrostatic exciton trap in a thin semiconductor membrane for optical coupling to a GaAs spin qubit

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Interfacing stationary solid-state qubits with photonic qubits would be a major milestone towards the realization of a quantum network[1]. Here, we propose a scheme to include an electrostatically-defined and optically active quantum dot at tunnel coupling range to a gate-defined quantum dot (GDQD)[2,3]. The platform requires thinning of the double-side doped heterostructure down to 220 nm membrane without degrading the optical and transport properties. We show that mobilities over 1×10^{6} $cm^2V^{-1}s^{-1}$ can be reached and that quantum point contacts and Coulomb oscillations can be observed on this structure. Besides, we demonstrate that exciton traps based on the quantum-confined Stark effect can be made provided depletion on the electron gas.

References

[1] H. J. Kimble, "The quantum internet," Nature 453, 1023–1030 (2008),
[2] M. D. Shulman et al., "Demonstration of entanglement of electrostatically coupled singlet-triplet qubits", Science 336, 202–205 (2012)
[3] R. Hanson et al., "Spins in few-electron quantum dots", Reviews of Modern Physics 79, 1217–1265 (2007)

Figures

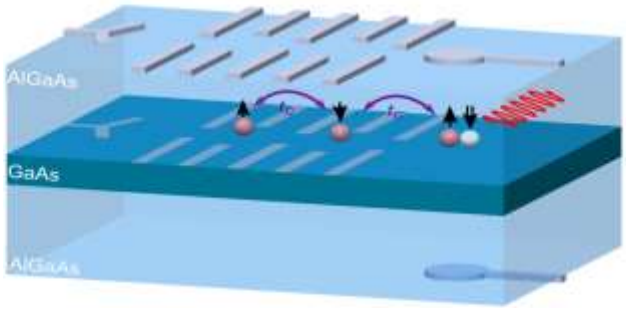

Figure 1: Sketch of an optical interface for GDQD (left side) based on an electrostatically-defined exciton trap (right side). The transfer of information is mediated by tunnel coupling t_C

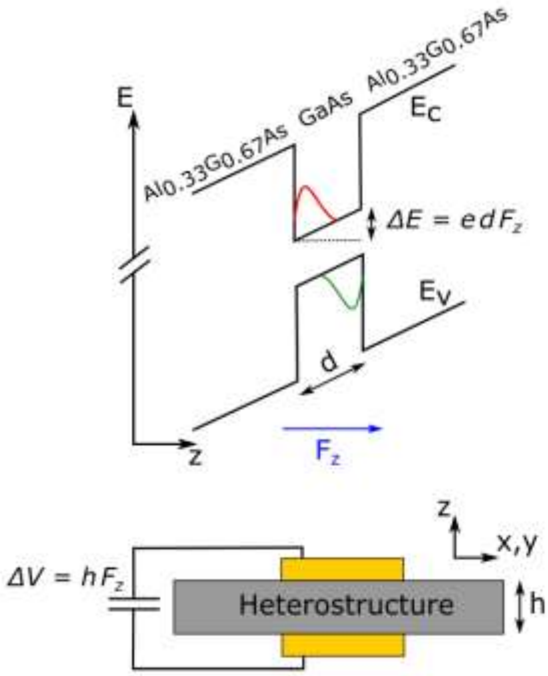

Figure 2: Quantum confined Stark effect on a $Al_{0.33}Ga_{0.67}As/GaAs/Al_{0.33}Ga_{0.67}As$ heterostructure resulting from an electric field F_z applied along the growth direction z. E_C and E_V are respectively the conduction and valence band. The electron and heavy hole ground state wave functions inside the quantum well are depicted.