Novel nano-template based quantum dot devices

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Semiconductor quantum dots have widely been viewed as a route to enabling quantum computing algorithms. For laterally gated quantum dots, one of the fundamental challenges towards realizing this goal has been the fabrication and integration of reproducible solid state qubits. Limitations arise from the inherent inhomogeneities that fabrication processes impart on these devices which in turn influence the wavefunctions required in quantum computing [1]. The implementation of nanotemplated structures, such as ridges and wires, for the fabrication of transport quantum dots structures is a novel technique which provides an avenue to addressing device reproducibility and scalability by confining 2DEG systems with minimized fabrication steps.

A series of quantum dot structures have been fabricated utilizing nanotemplate grown InP ridges with two types of embedded quantum wells: $In_xGa_{1-x}As$ and $InAs_xP_{1-x}$ [2]. The electrostatic confinement of these dots was achieved by using various combinations and spacing of finger gates (Figure 1), while attenuation and optimization of the electron density and mobility in the 2DEG ridge structures were accomplished by varying the ridge width and growth parameters. Preliminary results indicate that electron mobility values of these ridges approach that of planar InGaAs/InP 2DEG structures, ~ 100000 cm^2/Vs. Moreover, gated ridges exhibit mesoscopic characteristics, while transport data demonstrate Coulomb blockade peaks (Figure 2) – a clear indication of quantum dot formation.

It is envisioned that by designing and fabricating progressive 2DEG based controllable multiple quantum dot devices, as demonstrated, these structures can be integrated into functional quantum dot circuits with minimal effort. The devices presented would help to elucidate the confiment and transport properties of quantum dots in pre-patterned substrates.

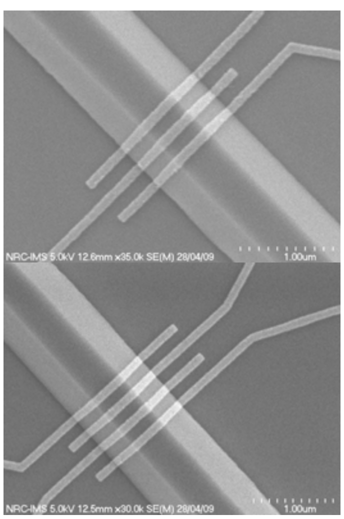

Figure 1: Gated ridges illustrating two types of gate combinations.

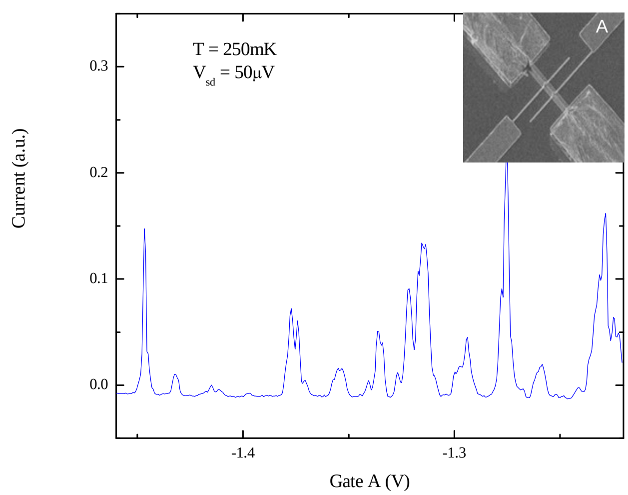

Figure 2: Coulomb blockade peaks through a quantum dot formed in ridge. Inset: gated ridge, W=0.7 µm, L=5 µm.

[1] R.W. Keyes, IEEE Computer Society, Computer, **38**, (2005) 65-69
[2] P.J. Poole, G.C. Aers, A. Kam, D. Dalacu, S. Studenikin and R.L. Williams, J. Crystal Growth, **310**, (2008)1069-1074