Non-invasive detection of single electron tunneling in a double dot device fabricated on GaAs using local anodic oxidation

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Abstract

We use AFM (atomic force microscope) nano-lithography technique in a Local Anodic Oxidation [1,2] process to fabricate a non-invasive single electron detector. Our detector is a one dimensional quantum channel whose resistance is electrically tunable with an in-plane side gate voltage. The detector is placed in close lateral proximity to a double quantum dot device which has extra in-plane side gates to control the tunneling of electrons between the dots and the electron reservoirs. Both the double dot system and the one dimensional detector constitute one integrated device fabricated with AFM lithography on an MBE (Molecular Beam Epitaxy)-grown GaAs/AlGaAs heterostructure with a two dimensional electron gas (2DEG) [3,4] confined 40 nm below the surface. We present experimental results showing Coulomb blockade oscillations as a direct evidence that our AFM-fabricated double dots do function as an electrically controllable SET (Single Electron Transistor). We furthermore present experimental evidence from low temperature electron transport measurements to demonstrate that the single electron tunneling in the double dot system can be monitored non-invasively with the lateral detector, making it possible to study electron dynamics in double dots without necessarily injecting invasive electrons across the dots. We draw a comparison of our results with those obtained on similar devices fabricated using alternative lithographic techniques and highlight the crucial role the AFM lithographic technique could play in the fabrication of future nano-electronic devices such as qubits for quantum computing experiments.

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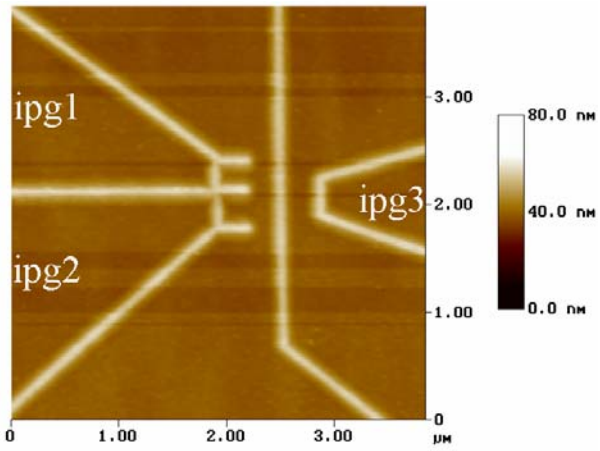

FIG 1: *An AFM image showing a double quantum dot device with a non-invasive lateral detector. The device was fabricated on GaAs/AlGaAs heterostructure using the AFM-based local anodic oxidation process.*