Quantum Multiplexer: A novel device architecture for low-temperature measurements

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Low-temperature semiconductor device physics is an area of intense research with a wide range of applications. However, research into this field suffers from limitations set by the small number of electrical contacts available on a single chip. The result is that only a few devices can be fabricated on a single chip, thus limiting the device or circuit complexity. Because of this, current research continues to be a slow, costly and time-consuming procedure where fabrication and measurement of several chips is necessary in order to study statistical variations of electrical characteristics and yield.

We present a novel low-temperature device architecture which significantly increases the number of electrical contacts locally available on a single chip, without the modification of existing fabrication or experimental setups. The 'Quantum Multiplexer' allows contact to a much larger number of mesoscopic devices on a single chip, as well as the design of more complex nano-scale circuits.

We demonstrate the applicability of the multiplexer to devices based on GaAs/AlGaAs heterostructures by presenting conductance measurements of 256 quasi-one-dimensional quantum wires formed by split-gate devices with common source-drain contacts on a single chip using only 19 electrical contacts. Yang *et al.* presented initial results [1-3] of statistical studies of split-gate characterisation, however, these measurements required many different chips to be tested on different cool downs. The advantage of our measurements is that they are conducted in a single cool down using common source-drain contacts, therefore eliminating variations in ohmic-contact resistance between devices. This provides a more comprehensive study of intrinsic yield and reproducibility through detailed statistical analysis of electrical characteristics such as one-dimensional channel definition, channel pinch-off and the '0.7 structure'.

The multiplexer makes a whole series of further, some intrinsically new, statistical investigations of both quantum phenomena and device fabrication/manufacturability possible. An incomplete list of possibilities include statistical studies of zero-dimensional quantum dots, parallel charge pumps, low-temperature shift registers and device analysis for quantum computing applications.

[1] Q.-Z. Yang, G. A. C. Jones, M. J. Kelly, H. Beere and I. Farrer, Semicond. Sci. and Technol. 21 558-64 (2006).

[2] Q.-Z. Yang, G. A. C. Jones, M. J. Kelly, H. Beere, and I. Farrer, Semicond. Sci. and Technol. 23 055018: 7pp (2008).

[3] Q.-Z. Yang, M. J. Kelly, H. Beere, I. Farrer and G. A. C. Jones, Appl. Phys. Lett. 94 033502 (2009).