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Observation of quantum effects in the electron transport characteristics of a nanocrystalline silicon point contact transistor — •Mohammed A. H. Khalafalla[1,3], Hiroshi Mizuta[1,3], Shunri Oda[1,3], and Zahid A Durrani[2,3] — [1]Quantum Nanoelectronics Research Centre, Tokyo Institute of Technology, O-Okayama, Meguro-ku, Tokyo 152-8552, Japan — [2]Department of Engineering, University of Cambridge, Trumpington Street, Cambridge CB2 1PZ, U.K. — [3]SORST JST (Japan Science and Technology), Japan.

Nanocrystalline silicon (nc-Si) devices are promising candidates for the development of quantum-dot (QD) transistors compatible with large-scale integration processes. These devices use nc-Si materials where nanometre-scale crystalline silicon grains naturally form large numbers of silicon QDs, isolated by tunnel barriers formed at thin amorphous silicon or silicon oxide grain boundaries. Furthermore, the small grain size leads to large electron-confinement. This paper reports on the observation of resonant tunnelling effects in the characteristics of the electron transport through a few nc-Si QDs embedded in a 30 nm times 30 nm channel of a point-contact transistor. Measurement at 4.2 K of the source-drain conductance as a function of the source-drain and gate voltages shows enhanced conductance resonances near zero source-drain bias and within the Coulomb gap in the negative source-drain bias range. This is associated with an enhanced electron transport between the source and drain contacts across an additional energy level formed within the Coulomb gap in a dominant nc-Si QD in the point contact channel. The formation of this level may be associated with a Kondo-like [1] effect arising from the strong coherent interaction [2] between the localised electrons in the nc-Si QD and the semi-free electron in the heavily doped source-drain contact regions through our thin (˜ 1 nm) grain boundary tunnel barriers. References:
[1]D. Goldhaber-Gordon, et al, NATURE, 391, 156 (1998). [2]M. A. H. Khalafalla et al Appl. Phys. Lett., 85, 2262 (2004).

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