Single-electron devices with a mechanical degree of freedom

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We have succeeded in integrating a single-electron transistor (SET) and a nanomechanical resonator into one device by suspending the SET island. In this case the island has flexural modes whose resonance frequencies depend on the material parameters and the island dimensions. The device is made of Al and can be studied in both the normal and superconducting state allowing observation of various physical phenomena. To couple mechanical motion to electronic transport, we apply a high, of the order of a few volts, dc voltage to the gate. By driving the resonator with an external force at a frequency close to the fundamental frequency of the flexural mode, we observe a characteristic feature in the dc SET transport, which is due to the mechanical resonance of the island. The resonance frequency as high as 0.5 GHz was detected. The observed response is reproduced in the simulations based on the semiclassical model of single-electron tunneling with the mechanical degree of freedom taken into account. Besides the studies of charge transport in single-electron circuits, the device can also be used for investigation of quantum effects in the charge qubits with a mechanical degree of freedom.