Abstract

In this thesis I present the results of my studies on tunable Josephson junctions. The samples are superconductor–semiconductor–superconductor junctions. Niobium was used as superconductor and an indium-arsenide two-dimensional electron gas as semiconductor. This material combination has the advantage of not having a Schottky barrier at the interface. An aluminium top-gate on the semiconductor makes it possible to tune the junction properties during the measurement.

Ballistic current transport through these junction is discussed in respect to Andreev reflection at the superconductor-normal conductor interfaces. A superconducting quantum point contact is realized by a split-gate geometry. The quantization of the conductance and the corresponding step-like dependence of the critical current as a function of gate voltage are observed in this superconducting quantum point contact. Good agreement with a theoretical model is shown.

Macroscopic quantum tunneling is also observed in the same type of superconductor–semiconductor–superconductor junction, a Josephson field effect transistor. The escape temperature and the noise-free critical current are extracted from statistics on the measured switching currents. The dependence of the escape temperature on bath temperature and on initial junction parameters is presented. The junction parameters are tuned *in situ* by varying the external magnetic field. In addition a sample has been capacitively shunted, increasing the junction capacitance. This is shown to increase the quality factor.

On the technical side a detailed description of various electrical filters and different schemes for magnetic shielding of low-temperature measurement setups is given. A suitable combination of filters with respect to attenuation and installation restrains is suggested. Magnetic shielding is realized through a combination of passive room temperature and low temperature μ-metal type shields.

Keywords: tunable Josephson junction, Andreev reflection, ballistic transport, superconducting quantum point contact, Josephson field effect transistor, macroscopic quantum tunneling