

Abstract

Current demands on computing technologies and storage units, such as speed, low power consumption, and high memory density, are leading to the development of new technologies. One promising area is superconducting cryoelectronics, including qubits, superconducting spintronics, or memory cells. Devices combining two antagonistic phenomena – superconductivity and ferromagnetism – have great potential. Many interesting effects can occur at their interfaces, such as the formation of π -junctions or triplet Cooper pairs, which allow the generation and transport of spin-polarized current. In this dissertation, we focused on the study of current transport through superconductor/ferromagnet/superconductor structures using a convex superconductor NbN and ferromagnetic layers with different degrees of spin polarization – NiCu, Ni, and Co. In the initial stage of the research, we first optimized the preparation process of S and F layers by pulsed laser deposition and carried out a detailed study of the supercurrent transport in continuous NbN layers with thicknesses of 10, 50, and 100 nm in magnetic fields at different angles. We showed that the nonlocal four-probe method is highly sensitive to the presence of superconducting inhomogeneities, and we proposed a model that allows their quantification. We further showed that due to a specific layer thickness d , lying between the coherence length ξ and the magnetic penetration depth λ ($\xi < d < \lambda$), there was a competition between two- and three-dimensional transport in the layer. Subsequently, we focused on the preparation and study of S/F/S micro- and nanostructures. These were prepared using both standard and advanced lithographic methods, namely optical lithography, ion etching, and focused ion beam. Transport measurements of the microstructures showed negative resistivities, which were explained using a model based on the Landauer-Büttiker approach. A multiple transition to the superconducting state was observed in the nanostructures, while the dependence of critical current on the magnetic field of the sample with ferromagnetic Ni layer indicated the presence of triplet Cooper pairs.

Key words: Superconductivity, magnetism, proximity effect