Frank Nikolaus Herbstritt: Ladungstransport und Rauschen in submikrometer-strukturierten Korngrenzenkontakten aus YBA 2 Cu 3 O 7-delta. 2002

Grain-boundary junctions made from high-temperature superconductors show a relatively high level of $1/f$-noise. To elucidate the origin of these low frequency fluctuations, grain-boundary junctions with cross-sectional areas between 0.002 and $0.02\mu m^2$ were fabricated from thin films and characterized with respect to their electrical transport and noise properties. The device fabrication was performed by growing 20 to 30nm thick epitaxial YBCO thin films on strontium titanate bicrystal substrates and subsequently patterning them using a combined photo- and electron beam lithography process. Due to the high sensibility of the cuprate material to structural damage and oxygen loss a proper optimization of the standard patterning procedure was required. By applying an ultra-violett light assisted post oxygenation process at 160°C to the readily patterned samples, their transport properties were significantly enhanced. Finally, we arrived at producing superconducting grain-boundary Josephson junctions with lateral dimensions down to 100nm.
Besides their various characteristics of quasiparticle conductivity, reaching from tunnelling-like behaviour to Andreev reflection dominated transport, a novel step-like feature in the current-voltage characteristics was observed in the vicinity of the critical current. Based on an extensive characterization of this reproducibly appearing effect it was found to be well explained as caused by an LC resonance between the large kinetic inductance of the narrow electrodes and the relatively high junction capacitances due to stray field contributions of the substrate material with its high dielectric constant. As another peculiarity of the current-voltage curves a striking stability against thermal rounding was observed. This could not be explained within the course of the thesis but might also be related to the resonance phenomenon.
By measuring and analyzing the noise spectra as well as time traces of the voltage fluctuations over a broad range of temperatures and voltages, the dynamic behaviour of individual fluctuating units was systematically investigated. The results confirm the findings of former studies and provide a more detailed view into the matter over an extended range of parameters. From this we find that the $1/f$-noise is caused by elementary switching processes between pairs of discrete conductance levels with an exponential distribution of lifetimes (TLF: two level fluctuators). The mean transition rates between the levels increase exponentially with applied bias voltage and show a thermally activated behaviour above some transition temperature around 5-15K. Below this temperature the rates become temperature independent. The voltage dependence of the rates decreases when the temperature is raised. Within narrow regions of the parameter space interactions between the fluctuators could be observed.
The investigated behaviour of the resistance fluctuations can be interpreted as caused by trapping and release of single charge carriers at defect states within the grain boundary region. A model of such trapping sites, originally developed by Rogers and Buhrman, yields a good quantitative agreement with the data, assuming reasonable estimations of the barrier parameters. Discrepancies of the model concerning the amplitude of the observed conductance fluctuations may be attributed to a considerable inhomogeneity of the barrier transmissivity on a length scale of a few nanometers.