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Tuning superconductivity by carrier injection

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All high-T_c cuprates are stacking sequences of CuO_2 layers and charge reservoir layers consisting of metal oxides. Upon doping the CuO_2 layers, antiferromagnetic order is destroyed and metallic conductivity is established. Usually doping is achieved by a non-stoichiometric composition of the charge reservoir layer. However, we already have shown that we can change the carrier concentration of $Bi_2Sr_2CaCu_2O_{8+\delta}$ single crystals by current injection along the c- axis [1]. Critical temperature, c-axis resistivity and critical current of intrinsic Josephson junctions can be tuned in a large range from underdoping to extreme overdoping. This effect is persistent up to annealing temperatures of approximately 270 K. Using current injection at higher bias, we were able to reduce the carrier concentration again. We investigated in detail the superconducting properties by performing macroscopic quantum tunneling experiments of intrinsic Josephson junctions. The experiments have been carried out repeatedly on samples, whose properties were changed only by current injection. An exponential increase of the critical current density with hole concentration was observed. At the same time, the capacitance of intrinsic Josephson junctions increased significantly. Finally, only by current injection, we were able to convert into the superconducting state a nonsuperconducting, oxygen depleted sample. This work was done in collaboration with Y. Koval, X.Y. Jin, S. Probst, Y. Simsek, C. Steiner (Universität Erlangen), H. B. Wang (NIMS, Tsukuba), and G. Behr, B. Büchner (IFW Dresden).

[1] Y. Koval, X.Y. Jin, C. Bergmann, Y. Simsek, L. Özyüzer, P. Müller, H. B. Wang, G. Behr, B. Büchner, Appl. Phys. Lett. **96**, 082507 (2010).