Structural Origin of the low Superconducting Anisotropy of Bi,Pb-2212 Crystals

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Systematic investigations were performed with the aim to improve the properties of $Bi_2Sr_2CaCu_2O_8$. The structure of Bi-2212 is modulated, the atom arrangement in the BiO layers changing from square meshes (rocksalt-type) to chains with a given periodicity. Due to the insertion of additional O atoms, the actual composition of these layers is Bi_9O_{10} ($Bi_2O_{2.22}$ per formula unit, leading to a total oxygen content per formula unit 8.22). This deviation from electroneutrality, which is partially compensated for by the presence of Bi^{3+} in the Ca layers, is a crucial parameter for the existence of the superconducting phase. By replacing part of the cations in Bi-2212 by chemically similar cations in a lower oxidation state it is possible to keep the same electron concentration, while removing the additional O atoms, thus suppressing the structural modulation. This was achieved by substituting ~22% of Bi^{3+} by Pb^{2+}. The arrangement of atoms in the BiO layers in modulation-free Bi,Pb-2212 can be considered as distorted rocksalt-type. The cell parameter along the stacking direction is slightly larger for Bi,Pb-2212 than for the Pb-free phase. However, the distance between the two Bi layers is decreased by 0.13 Å, which is in agreement with the fact that these layers are no longer corrugated but planar. The superconducting anisotropy of the Pb-doped crystals was found to be reduced with respect to undoped ones. Consequently, modulation-free Bi,Pb-2212 has an enhanced irreversibility field and a lower relaxation rate than in modulated Bi-2212.

Keywords: high-T_c superconductor, modulated structure, structure-property relationship