A Systematic Optical Study of Phonon Properties in Optimally Doped $Bi_2Sr_2CaCu_2O_{8+\delta}$ Single Crystals

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Infrared spectroscopy is often used to investigate the question of electron-phonon interaction in 'bad' metals, particularly in high T_c cuprates, because both the electronic properties and phonon properties can be studied simultaneously. In view of the renewed suggestion that charge-phonon coupling is the mechanism for superconductivity in high T_c cuprates, charge-phonon interaction needs to be examined more carefully in these systems. Previously, the problem of phonon screening has been examined in optimally doped $Yba_2Cu_3O_{6.95}$ [1]. In this work, a systematic study of infrared-active phonons is carried out for optimally doped $Bi_2Sr_2CaCu_2O_{8+\delta}$ (OP Bi2212) single crystals along c-axis as well as in the ab-plane. Because of the high signal-to-noise ratio achieved using our *in situ* evaporation technique, infrared-active optic phonons have been observed for the first time in the ab-plane for OP Bi2212. Similar to the previous results, there is only a weak dependence of the conductivity on the direction of the E-vector within the ab-plane. However, strong phonon anisotropy has been observed in our ab-plane conductivity measurements despite the fact that the lattice parameter shows little difference along a or b-axis. Particularly, the mode at 477 cm^{-1} is only observed with E-vector parallel to a-axis but not with E-vector parallel to b-axis while the 630 cm^{-1} mode is present in both polarizations. More interestingly, there is a mode at 310 cm^{-1} for E-vector parallel to b-axis (but not a-axis) that shows up as an anti-resonance in σ_1 indicating that this mode is coupled to the charges in the system. The observed phonon anisotropy is presumably related to the extra Bragg peaks observed along b-axis for OP Bi2212 in both X-ray and neutron experiments.

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