FIR In-plane Conductivity of YBaCuO Studied by Studied by Spectral Ellipsometry

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Using the technique of spectral ellipsometry [1,2], we have measured the far-infrared (FIR) optical conductivity along the a-direction (perpendicular to the CuO chains) for two detwinned $YBa_2Cu_3O_{7-d}$ single crystals, one oxygen deficient and underdoped (T_c=80K), the other almost fully oxygenated and thus near optimum doping (T_c=91.5 K). In addition, we have studied the FIR in-plane conductivity of a thin film of $Y_{0.8}Ca_{0.2}Ba_2Cu_3O_{6.9}$, which is strongly overdoped (T_c=75 K). Our data complement previous measurements with conventional reflection techniques [3]. The normal state spectra are composed of a rather narrow Drude-like component, which is superimposed on a broad absorption band, which extends far into the mid-infrared (MIR) spectral range (MIR-band). The magnitude of the MIR-band is largest for the optimum doped crystal. In the superconducting state a pronounced dip develops in the FIR-range, which separates the still sizeable Drude-like component (which remains even at the lowest temperature of T=10K <<T_c) from the MIR-band. The energy of the dip position (as indicated by the arrows) decreases from about 420 cm^{-1} for the underdoped crystal, to 320 cm^{-1} for the optimum doped one and 180 cm^{-1} for the overdoped sample. The Drude-like peak is always well separated from the onset of the MIR absorption band. Apparently, the width of the Drude-like peak is correlated with the onset energy of the MIR-absorption band. This finding seems to indicate that both features have a common origin. Recently, a theory has been proposed which explains the MIR-band and thus the occurrence of the dip feature in terms of the inelastic scattering of the charge carriers on spin-fluctuations [4,5]. The decrease of the dip energy with doping thus indicates a decrease of the characteristic energy scale of the spin-fluctuations and the pair-breaking processes [4]. The Drude-like peak, on the other hand side, is not accounted for within this theory. It is rather assumed that it arises from extrinsic effects such as scattering of the charge carriers on structural or magnetic impurities, which leads to strong pair-breaking especially in d-wave superconductors. In contrast, our present data imply that the Drude-like peak is an intrinsic feature just like the MIR-band.

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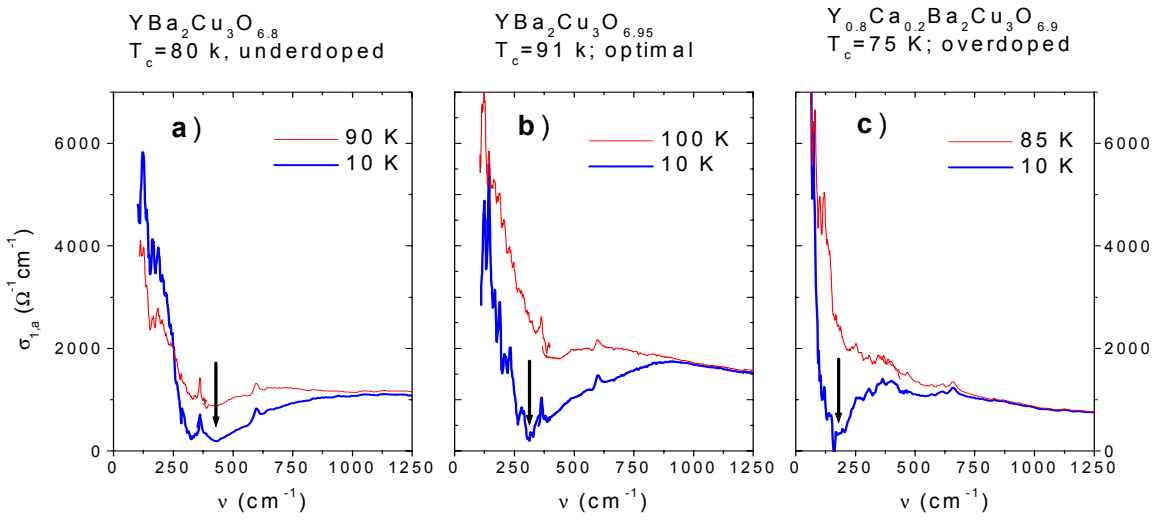

Figure 1. FIR in-plane optical conductivity of underdoped, almost optimally doped and overdoped YBaCuO. Shown are spectra for the polarization along the a-axis, i.e. perpendicular to the CuO chains for a and b. The arrows indicate the position of the dip in the low-T conductivity.