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A BiSrCaCuO 2212 phase single crystal was grown by a directional solidification method. The ac susceptibility versus temperature curve is given. Some structural analyses were carried out. The measurements of reflectivity spectra by polarized light have been performed on the (001) plane in the wavelength range from 0.6 to 1.7 μm at room temperature. The spectra of both a and b-axis directions are characterized by a strongly damped plasma edge of similar shape. By fitting the Lorentz–Drude model we get some quantitative results, which may be related to the structural features of the BiSrCaCuO 2212 phase single crystal.

Since the discovery of superconductivity in the BiSrCaCuO,[1] a lot of physical properties of Bi-based cuperates have been studied. Because of the difficulty in preparing high quality large BiSrCaCuO single crystal, there have been few reports on the anisotropic properties within the a-b plane. Recently we have grown large single crystals of BiSrCaCuO by the directional solidification method.[2] The structural study has shown that the quality of the single crystal by this method is better than other methods, such as the flux method. One more fascinating point of the crystal is its perfect cleavage along (001), which is an advantage for the study of the reflectivity spectra.[3] The optical study of the doping effect in single-crystal Bi-based cuperates was reported by Terasaki *et al.*[4] We report the result of the polarized reflection measurements on the (001) plane of BiSrCaCuO single crystal in this letter.

The samples were prepared by the directional solidification method. A mixture of 99% pure Bi_2O_3, $SrCO_3$, $CaCO_3$, and CuO powder was reacted at 800 °C for 24 h. Then it was put into a highly pure alumina crucible ($>99.5\%$ Al_2O_3) and melted at 1050 °C. Finally, crystals were grown in the crucible by a modified Bridgman–Stockbarger method. The maximum single crystal is up to $19\times3\times2$ mm^3 (shown in Fig. 1). The measurement of the chemical composition of the crystal shows that there is no Al contamination in the single crystals.

The sample used in the experiment was treated in air at 590 °C for 72 h. It has very well reflecting cleavage surface. The x-ray diffraction pattern measured along the cleavage plane of the single crystal is shown in Fig. 2. It shows that the cleavage plane is (001). The a and b axes of the single crystal were identified by the Laue method.[3] The size of the sample is $5\times2.5\times1$ mm^3. The cleavage surface is a large and well reflecting plane with 5×2.5 mm^2. The ac susceptibility measurement result of this sample is shown in Fig. 3. The transition temperature is $T_c = 81$ K.

The optical reflectivity spectra were measured in the wavelength range from 0.6 to 1.7 μm at room temperature. For polarization direction parallel to the a and b axes the reflectivity spectra $R\|a$ and $R\|b$ are shown in Fig. 4. The electric field E of the incident light was perpendicular to the c axis ($E\perp c$). From Fig. 4 we can see that the spectra of both crystallographic directions are characterized by the plasma edge (at $\hbar\omega = 1.1$–1.3 eV), in agreement with Ref. 4.

We tried to fit the reflectivity spectra to the Lorentz–Drude model. The dielectric function used for fitting is given as follows:

$$\epsilon(\omega)=\epsilon_\infty-\frac{\omega_D^2}{\omega^2+i\omega\gamma_D}+\frac{\omega_L^2}{\omega_0^2-\omega^2-i\omega\gamma_L}+\cdots, \quad (1)$$

where

$$\omega_D^2=4\pi n_D e^2/m^*$$

and

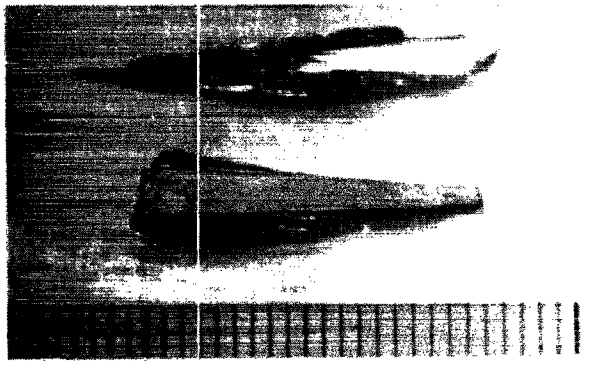

FIG. 1. Large single crystal of BiSrCaCuO 2212 phase cleavaged from a directionally grown specimen (scale: 1 div/mm).

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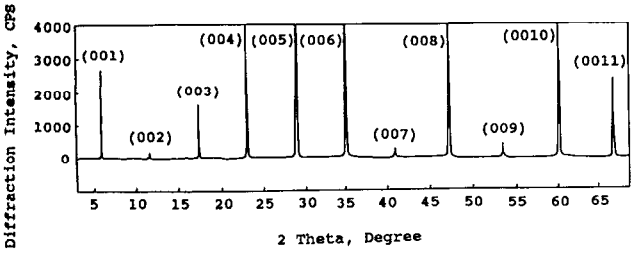

FIG. 2. X-ray diffraction pattern of the (001) plane of the BiSrCaCuO 2212 phase single crystal with the Cu K_a radiation, 40 kV, 100 mA.

$$\omega_L^2 = 4\pi n_L e^2/m^*.$$

The first term ϵ_∞ in Eq. (1) represents the optical dielectric constant. The second term corresponds to a Drude model describing the plasma excitation. The last term corresponds to a Lorentz oscillator describing mid-IR excitation. The parameters ω_0, ω_L, and γ_L remain somewhat uncertain and precise fitting is difficult, but the parameters ω_D,γ_D can be almost uniquely determined. We obtained $\hbar\omega_{Da} = 1.1$ eV, $\hbar\gamma_{Da} = 0.12$ eV, $\hbar\omega_{Db} = 1.3$ eV, $\hbar\gamma_{Db} = 0.05$ eV for $R\|a$ and $R\|b$, respectively. These results correspond to $\tau_a \sim 1/\gamma_{Da} = 5.0\times10^{-15}$ s, $\tau_b \sim 1/\gamma_{Db} = 1.3\times10^{-14}$ s.

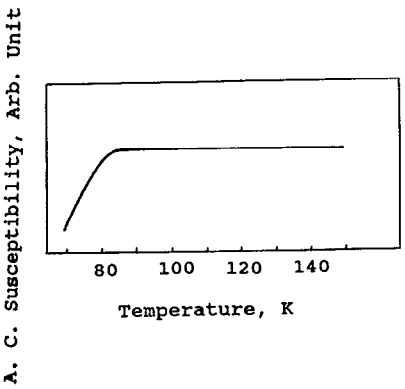

FIG. 3. ac susceptibility vs temperature curve of BiSrCaCuO single crystal.

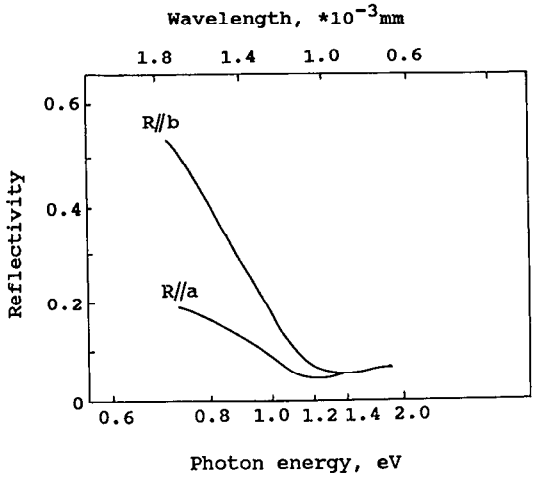

FIG. 4. Reflectivity spectra of the BiSrCaCuO single crystal within the (001) plane as functions of wavelength and photon energy of the incident light (at room temperature).

Koch *et al.* measured $R\|a$ and $R\|b$ for YBaCuO single crystal and a large anisotropy was found.[5] They attributed the anisotropic properties to the difference between the Cu-O chain and Cu-O plane. The anisotropy of reflectivity of single-crystal BiSrCaCuO in the *a-b* plane may possibly arise from its structural features. Further study means to be carried out in order to explain the reason satisfactorily.

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