TRANSPORT PROPERTIES OF SmBa$_2$Cu$_3$O$_{6.2}$ SINGLE CRYSTAL

V.KOVACIK, V.V.MOSHCHALKOV, V.N.NIKIFOROV, L.I.LEONYUK

Laboratory of High-T$_c$ Superconductivity, Physics Department, Moscow State University, Moscow GSP-119899, USSR.

Resistivity, Hall effect and transverse magnetoresistance of SmBa$_2$Cu$_3$O$_{6.2}$ single crystal were studied at temperatures 4.2+260 K in magnetic fields up to 4 T. A large conductivity anisotropy of about $\sim$10$^{3}$ at 4.2 K has been found. The free charge carriers concentration deduced from the Hall effect measurements is characterized by the activation law with the energy $E_{AH}=13$ meV. Negative magnetoresistance in magnetic field $B=3T$ is observed at $T>50$ K. These results are discussed in terms of the hopping conductivity model.

1. INTRODUCTION.

Most of the REBa$_2$Cu$_3$O$_{6+x}$ systems (where RE denotes the rare earth ion) are antiferromagnetic insulators for $x<0.35$ and high temperature superconductor for higher $x$. In the insulating state these compounds demonstrate variable range hopping (VRH) behavior of the resistivity$^{2,3}$, but available experimental data in this oxygen concentration range are insufficient to analyze the type of hopping conductivity.

In order to address this issue we carried out measurements of the resistivity anisotropy, Hall effect and transverse magnetoresistance of the insulating SmBa$_2$Cu$_3$O$_{6+x}$.

2. EXPERIMENTAL.

Single crystalline SmBa$_2$Cu$_3$O$_{6+x}$ with characteristic dimensions 4x3x0.2 mm$^3$ was grown by the permanent crystallization from the liquid phase and corresponds to the oxygen content $x=0.2$.

3. RESULTS.

Resistivity, both parallel ($\rho||$) and perpendicular ($\rho\perp$) to the C-O planes (see fig.1), demonstrates a thermal activation law with the corresponding energies $E_{A||}=(35\pm1)$K and $E_{A\perp}=(45\pm3)$K in the temperature interval (20<T<50)K. Below 20 K VRH behavior $\rho=\rho_0\exp(T_0/T)\alpha$ was observed, where corresponding parameters for $\rho||$ and $\rho\perp$ are $\alpha||=0.35\pm0.01$, $T_0||=(2600\pm300)K$ and $\alpha\perp=0.33\pm0.01$, $T_0\perp=(8400\pm1600)K$. Resistivity anisotropy ratio $\rho\perp/\rho||$ increases with decreasing temperature and equals to 57 at 200 K and 280 at 10 K.

Fig. 1

Hall effect and magnetoresistance measurements were carried out in the low field regime ($H\cdot B<4\times10^{-2}$). Activation dependence of the Hall constant $R_H$ with energy $E_{RH}=150\pm60$K and maximum on the Hall mobility $\mu_H$ at
The results on the anisotropy of resistivity gives evidence for highly anisotropic nature of the charge carrier spectrum in SmBa$_2$Cu$_3$O$_{6+x}$. An increase of the $\rho_L/\rho_T$ ratio with decreasing temperature is rather surprising because average hopping distance becomes larger at lower $T$ and hops between C-O layers are more probable, thus we could expect the opposite behavior of the $\rho_L/\rho_T$. Then the VRH behavior would be considered as three dimensional and the value $\omega=1/3$ may be attributed to the crossover between Shklovski-Efros ($\omega=1/2$) and Mott's law ($\omega=1/4$).

The observed temperature dependence of $\mu_H$ we attribute to the charge carrier scattering by phonons, as in ordinary semiconductors.

Magnetoresistance behavior may be explained within the framework of interplay between Anderson localisation and Coulomb interaction effects.

REFERENCES.