Physica C 162-164 (1989) 1019-1020
North-Holland

LOCALIZATION EFFECTS IN DISODERED HIGH-T_c SUPERCONDUCTORS

B.N.Goshchitskii, S.A.Davydov, A.E.Karkin, A.V.Mirmelstein, M.V.Sadovskii, V.I.Voronin

Institute for Metal Physics, USSR Academy of Sciences, Ural Branch, 620219 Sverdlovsk GSP-170, USSR

Investigations of the effects of disorder in HTSC induced by fast neutron irradiation at T=80K show that localized effects are essential even at small disorder in states with high enough Tc. Localization leads to a decrease in Tc and full suppression of superconductivity within the range of strong localization.

1. INTRODUCTION

As known the YBCO and LSCO systems with decreasing oxygen and strontium concentration, respectively, show the transition from the superconducting "metallic-like" state to antiferromagnetic insulator. We have investigated the influence of fast neutron irradiation at liquid nitrogen temperature on physical properties of YBCO, LSCO and BSCCO and found that radiation-induced disorder also results in the insulator state of the system[1-3]. On the basis of the experimental data we may assert that the chemical composition of HTSC in this case does not change and the above transformation results from the introduction of the chaotic potential only. Hence the Anderson metal-insulator transition takes place . From this point of view it is possible to explain a number of the observed effects, in particular, degradation of T_c under disorder.

2. RESULTS AND DISCUSSION

The experimental details are given in Ref.1-3, which evidence for the localized states (LS) in the system well before than it may be judged by the typical temperature dependence of electrical resistivity

$$\rho(T)=a\exp(Q/T^{1/4})$$
$$Q=2.1[N(E_F)R_{loc}^3]^{-1/4} \qquad (1)$$

Assuming strong two-dimensional anisotropy of conductivity in HTSC it may be concluded[2] that the minimal metallic conductivity may reach the value of $10^3(\mathrm{Ohm\cdot cm})^{-1}$. Hence even the initial HTSC samples may be considered to be close to Anderson transition.

In general, superconductivity may exist in the system providing that the value of the superconducting gap $\Delta(T=0)$ is essentially higher than splitting between the LS lying within the localization radius:

0921-4534/89/$03.50

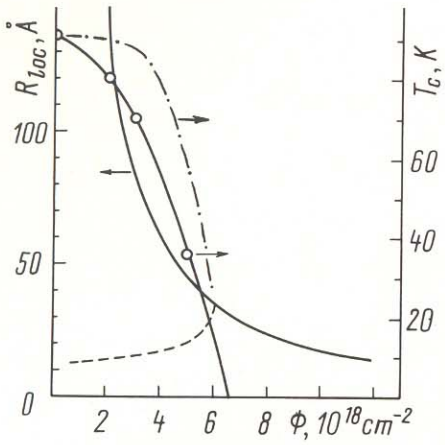

FIGURE 1
Rloc (solid line) and Tc (circles) vs. fluence of fast neutrons Φ for YBCO. Dots show Rloc calculated by (2). The dash-dot line shows the value of Tc according to (3).

$$\Delta \sim T_C >> [N(E_F)\, R_{loc}^3]^{-1}. \qquad (2)$$

Therefore it may be concluded that suppresion of superconductivity is not connected with the appearance of LS itself but rather with the essential decrease of R_{loc} with increasing disorder. According to Ref.4 we may calculate T_C vs. R_{loc} (i.e. vs. extent of disorder) that may be found experimentally[2]:

$$\ln(T_{C0}/T_C) =$$

$$= \Psi(1/2+\mu/4T_C\, N(E_F)R_{loc}^3)-\Psi(1/2) \qquad (3)$$

where Ψ is the digamma function, μ is the Coulomb potential. Fig.1 shows good qualitative agreement between the experimental and calculated results.

This approach helps to elucidate also some other peculiarities in the behavior of the disordered HTSC. In particular, the decrease of R_{loc} may account for the appearance of the effective magnetic moments (EMM) in strongly disordered samples[1]. When the Fermi level is well below the mobolity edge EMM p^2_{calc} (in Bohr magneton) is[2]:

$$p^2_{calc} = \mu V_0 R_{loc}^{-3} \qquad (4)$$

where V_0 is the unit cell volume. For R_{loc} = 8 Å ($\Phi=2\times10^{19}$ cm^{-2}) and μ=1 we get p^2_{calc}=0.66 for YBCO in good agreement with the experimental value p^2_{exp}=0.661[1]. At smaller Φ, however, when R_{loc} is not small enough p^2_{exp} >> p^2_{calc}.

In conclusion, the experimental results show that investigation of disordered state induced by fast neutron irradiation and genetically connected with the peculiarities of HTSC in the ordered state with high enough T_C is of great interest for understanding the nature of these surprising materials. Even at the smallest disorder in HTSC pairing occurs in the system of localized electrons. The decrease in R_{loc} diminishes T_C and fully suppresses superconductivity at high disorder.

REFERENCES

1. B.A.Aleksashin et al., Physica C153-155 (1988) 339.

2. B.A.Aleksashin et al., JETP 95 (1989) 678.

3. S.A.Davydov et al., Int.J.Mod.Phys. B3 (1989) 87.

4. L.N.Bulaevskii and M.V.Sadovskii J.Low Temp.Phys. 59 (1985) 89.