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BRIEF COMMUNICATIONS

EFFECT OF EXPOSURE TIME IN NITROGEN ON THE SUPERCONDUCTING PROPERTIES OF YBCO CERAMICS

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The main task of research in high-temperature superconductivity (HTSC) remains the problem of enhancing the superconducting properties of materials. It is known that impurities have a substantial positive effect on the superconducting properties of the HTSC $YBa_2Cu_3O_y$ (YBCO) ceramic (critical temperature and width of the superconducting transition T_C and ΔT_C; critical current density J_c; and critical magnetic fields H_{c1} and H_{c2}) [1]. It has been established for a number of impurities that their presence in the ceramics at concentrations of 10^{-4}–10^{-1} at.% leads to an increase in T_C by 1–5 K and to a decrease in the width of the superconducting transition ΔT_C [2].

In this work, nitrogen atoms are used as the impurity in YBCO to enhance its superconducting properties. Studies of the effect of the exposure time of YBCO ceramics in a nitrogen atmosphere on its superconducting properties have been carried out.

$YBa_2Cu_3O_y$ samples were synthesized using a well-known ceramic technique: a mixture of yttrium oxide, copper oxide, and barium carbonate was held at a temperature of 920°C for 24 h in air with subsequent sintering and annealing in an oxygen atmosphere at a temperature of 450°C for 20 h and slow cooling in oxygen. The density of the synthesized ceramics was 5.5 g/cm^3 [3].

The sample was placed in nitrogen gas and cooled to 77 K, and then, as its temperature was raised, the dependence $R(T)$ was measured by the four-probe technique. Figure 1 displays the temperature dependence of the resistance as a function of exposure time of the YBCO ceramics in nitrogen gas in the low-temperature region.

The maximum heating temperature of the samples in all the experiments did not exceed 200 K. The samples were exposed to nitrogen gas at 77 K. After holding the sample for 4 h, its superconducting transition temperature T_C increased by 16 K. Subsequent exposure for 8 h relative to the starting time led to an increase in T_C by 25 K in comparison with its initial value. Finally, when the total exposure time of the $YBa_2Cu_3O_y$ sample in nitrogen gas was 12 h, the critical temperature T_C approached 135 K.

Thus, we have experimentally shown that consecutive increase in the exposure time of $YBa_2Cu_3O_y$ ceramics in a nitrogen atmosphere at low temperatures leads to an increase in T_C from measurement to measurement, up to $T_C \approx$ 135 K. This allows us to conclude that doping of $YBa_2Cu_3O_y$ with nitrogen atoms leads to a change in the superconducting transition temperature. The observed effect of an increase in T_C may be associated with doping of nitrogen atoms and molecules into the ceramics. Doping of nitrogen molecules into the solid phase of the ceramic can be realized by either bulk diffusion or by diffusion along grain boundaries and microcracks. It may also be supposed that the observed effect is associated with incorporation of nitrogen atoms into the crystal structure of $YBa_2Cu_3O_y$.

The experimental results presented here require careful theoretical and practical follow-up in the direction of enhancing the characteristics of the transition to the superconducting state. It is obvious that to examine these properties further, high-quality crystals with highly-accurate prescribed content of impurity elements in YBCO are needed.

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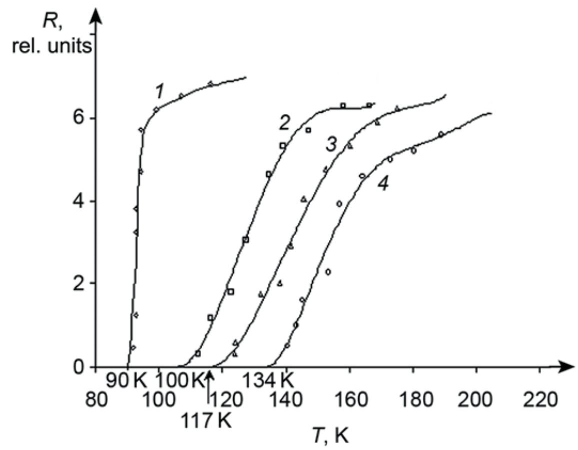

Fig. 1. Temperature dependence of the resistance for different exposure times of the ceramic $YBa_2Cu_3O_y$ in nitrogen gas at low temperatures: curve *1* is for $t = 0$, curve *2* is for $t = 4$ h, curve *3* is for $t = 8$ h, and curve *4* is for $t = 12$ h.

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