Similarity of thermal expansion anomalies in MgB_2 and HTS oxides

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Abstract

The measurements of thermal expansion $\alpha(T)$ of MgB_2 were carried out at low temperatures both in zero magnetic field H and at $H \approx 4T$. As for oxide high-temperature superconductors (HTS) the anomalous (negative) thermal expansion was observed for MgB_2. It was found also the strong magnetic field influence on the $\alpha(T)$. Qualitative explanation of both effects on the basis of known charge density wave properties was given. The results indicate on the similarity of the anomalous properties of MgB_2 and oxide HTS.

Key words: thermal expansion; magnetic field; HTS; anomaly

The thermal expansion of MgB_2 and the magnetic field influence on it were measured at $T \leq 60K$ and $H \leq 4T$. The samples were obtained by the hot high-pressure method. Measurements of electric, magnetic, structural, and other properties tested the quality of these samples. In particular, the large specific heat jump was observed at $T_c \approx 40K$. The density of the samples was 97% of the ideal X-ray density. The linear thermal expansion of samples $\Delta L/L$ was measured by the strain-gauge method with the sensitivity about 10^{-7} [1]. Magnetic field was parallel to the deformation direction.

The temperature dependence of the thermal expansion $\Delta L/L$ for MgB_2 at $H = 0$ is shown in the Fig.1a. The data for $YBa_2Cu_3O_{7-x}$ [2], $Bi_2Sr_2CaCu_2O_8$ [3], $La_{1.9}Sr_{0.1}CuO_4$ [4], and $Ba_{0.87}K_{0.13}BiO_3$ [4] obtained earlier are given in the Fig.1b. For MgB_2 the thermal expansion coefficient $\alpha = \frac{1}{L}\frac{\partial L}{\partial T}$ is negative in temperature interval about $T \leq 11K$. One can see from Fig.1b that in oxide HTS at low temperatures there are also areas of negative thermal expansion $\alpha(T)$. Thus MgB_2 compound exhibits the same anomalous property ($\alpha < 0$ at low temperatures) as the oxide HTS.

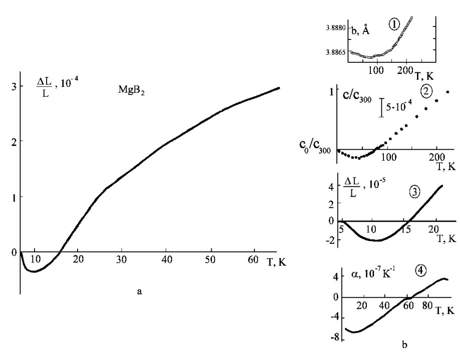

Fig. 1. Temperature dependence of the thermal expansion $\Delta L/L$ for: a. MgB_2; b. 1) $YBa_2Cu_3O_{7-x}$ (b-lattice parameter along "b"-axis) [2]; 2) $Bi_2Sr_2CaCu_2O_8$ (c-lattice parameter along "c"-axis, c_o, c_{300}-lattice parameters at $T \leq 4K$ and 300K) [3]; 3) $La_{1.9}Sr_{0.1}CuO_4$ ("ab"-plane) [4]; 4) $Ba_{0.87}K_{0.13}BiO_3$ [4].

The influence of the magnetic field $H = 36kOe$ on the temperature dependence of the $\Delta L/L$ for MgB_2 is shown in the Fig.2a. For comparison the influence of the magnetic field on the dependence of the $\Delta L/L$ for

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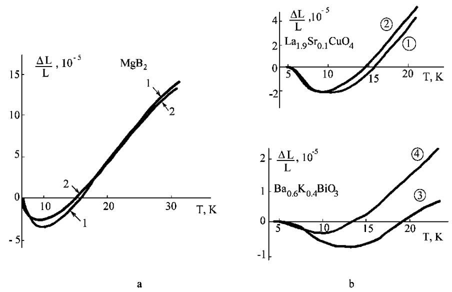

Fig. 2. Influence of magnetic field on the temperature dependence of the thermal expansion $\Delta L/L$: a. MgB_2 (curve 1-$H = 0$; curve 2-$H = 3.6T$); b. $La_{1.9}Sr_{0.1}CuO_4$ (curve 1-$H = 0$; curve 2-$H \approx 4T$) and $Ba_{0.6}K_{0.4}BiO_3$ (curve 3-$H = 0$; curve 4-$H = 4T$) [4].

$Ba_{0.6}K_{0.4}BiO_3$ and $La_{1.9}Sr_{0.1}CuO_4$, also founded by us, is presented in Fig.2b. One can see that influence of the magnetic field $H \sim 4T$ on the $\alpha(T)$ magnitude at low temperatures are anomalously strong for such materials and area with negative α moves to lower temperatures with growing H.

Both in MgB_2 and oxide HTS systems the anomalous (negative) thermal expansion at low temperatures and influence on it of the magnetic field can be explained by influence of charge density waves on the crystal lattice stability [4]. From the observed similarities of properties of HTS and MgB_2 shown in Fig.1 and 2 one can suppose similarities in the nature of the anomalies.

Acknowledgements

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References

[1] N.V.Anshukova et al. Intern. J. Modern Phys. B**12** (1998) 3251.

[2] H.You et al. Phys. Rev. B**43** (1991) 3660.

[3] Z.J.Yang et al. J. Supercond. **8** (1995) 223.

[4] N.V.Anshukova et al. JETP Letters **71** (2000) 377.