Two-gap nature of superconductivity: 25 years after its discovery in MgB_2

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Shortly after the formulation of the BCS theory, its extension was proposed, taking into account two-band superconductivity and interband scattering [1]. The first superconductor with two energy gaps turned out to be $SrTiO_3$ doped with Nb [2]. In 2001, pioneering research demonstrated the superconductivity in MgB_2 [3] and the two-gap nature of the superconducting state of this compound (see, for example, Ref. [4]).

Magnesium diboride features a layered atomic geometry where graphite-like honeycomb sheets of boron atoms alternate with hexagonal layers of magnesium atoms, with the Mg atoms centered above and below the boron hexagons, giving rise to two types of electronic bands, which results in two gap superconductivity. Its critical temperature of 39 K is surprisingly high, taking into account that the mechanism is driven by the BCS theory, is unique due to its multi-band nature. The two-gap nature of the superconducting state of this compound was demonstrated using several experimental techniques (see, for example, Ref. [4]). The dependence of the second critical field anisotropy, $\gamma_H = H_{c2}^{\|ab}/H_{c2}^{\|c}$, on temperature and magnetic field was determined (changing in the range of 6–3, with increasing temperature) and its relationship with the two-gap nature of the superconducting state was shown [5]. The effects of electron and hole doping on superconducting parameters were investigated, and the complex phase diagram of vortex matter in MgB_2 was discussed [6].

It was shown that the values of anisotropy γ for MgB_2 strongly depend on temperature and chemical substitutions [5, 6]. The practical significance of the conducted research relates to the possibility of optimizing the parameters of the superconducting state in MgB_2, and their conclusion is that without a certain reduction of the critical temperature, it is unfortunately impossible to obtain a material with a high value of the upper critical field. However, thanks to its high T_c, relatively low anisotropy, and absence of weak links at grain boundaries, MgB_2 is considered as a promising material for superconducting applications at 20 K and moderate magnetic fields (wires and tapes).

References

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