Promising material shows new evidence of unconventional superconductivity

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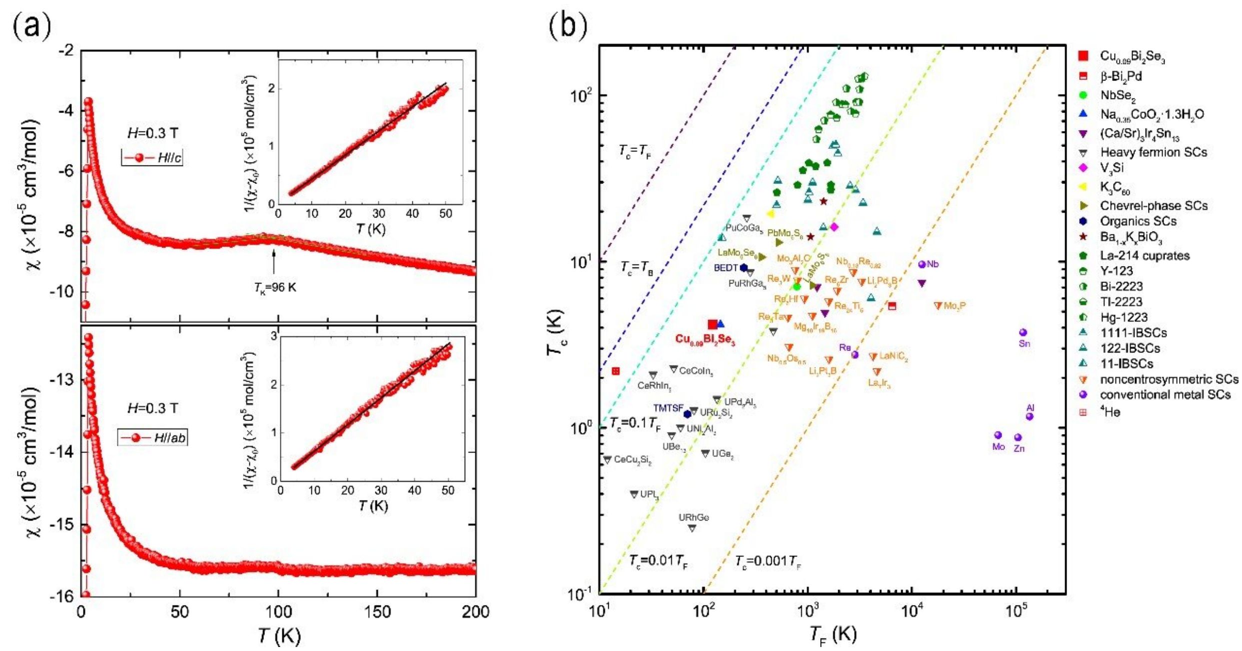

(a). Temperature dependence of magnetic susceptibility under 0.3 T for H//c & H//ab; (b). Ratio of Tc/TF2D provides the experimental evidence of CuxBi2Se3 as an unconventional superconductor. Credit: SIOM

In recent years, the search for non-trivial topological materials has become a hot topic in condensed matter physics. Since Hor et al, first reported the discovery of superconductivity in Cu doped topological material Bi_2Se_3 in 2010, the $Cu_xBi_2Se_3$ has become one of the most promising materials as topological superconductor due to its unique physical properties and crystal structure. However, the superconducting transition temperature Tc up to 3.8 K in $Cu_xBi_2Se_3$ is unexpectedly "high" for a low carrier density semiconductor. So far, the mechanism of such anomalous enhanced Tc phenomenon remains unclear despite nearly a decade of extensive research.

In a recent work conducted by Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, high quality single crystal of $Cu_xBi_2Se_3$ was grown by modified Bridgman method. The Tc of the as-grown crystals with x=0.09 could reach 4.18 K, which was the highest one among reports on $Cu_xBi_2Se_3$ so far.

A systematic study of the magnetic susceptibility, critical fields, and electrical transport on the $Cu_{0.09}Bi_2Se_3$ single crystals were conducted to explore the unusually enhanced Tc and its superconducting properties.

Interestingly, a novel kink in the magnetic susceptibility versus temperature was observed at 96 K, which indicated a charge density anomaly, probably charge density wave (CDW) transition.

The analysis of the magnetoelectrical transport at low temperature yielded a high Kadowaki-Woods ratio, which might be enhanced by the charge density instability and/or strong electronic anisotropy.

Based on the lower critical field measurement, the energy gap ratio Δ0/kBTC was found obviously larger than the standard BCS value 1.764, suggesting the $Cu_{0.09}Bi_2Se_3$ a strong-coupling superconductor. Ratios of both Tc/TF2D and Tc/λ-2(0) fell into the region of unconventional superconductors according to Uemura's regime, supporting the unconventional superconducting mechanism in $Cu_xBi_2Se_3$.

Their research proposed that the high Tc in $Cu_xBi_2Se_3$ arises from the increased density of states at Fermi energy and strong electron-phonon interaction induced by the charge density instability.

The results suggest the higher Tc in $Cu_xBi_2Se_3$ could be further achieved by gating-technique or high pressure technique, as realized in iron-selenides superconductors.

Provided by Chinese Academy of Sciences

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