Microstructure and superconducting properties of $KCa_2Fe_4As_4F_2$ single crystals

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The recently discovered compound $ACa_2Fe_4As_4F_2$ (A = K, Rb, Cs) is a layered iron-based superconductor [1] with a critical temperature T_c from 28 to 34 K. The $ACa_2Fe_4As_4F_2$ compound has a complicated crystal structure. The double layers of FeAs are separated by insulating layers of Ca_2F_2. This layered structure leads to significant anisotropy of superconducting properties. In this work, $KCa_2Fe_4As_4F_2$ the single crystals were grown by "self-flux" method (KAs) [2]. The 12442 ($KCa_2Fe_4As_4F_2$) superconductor has a narrow crystallization range and is formed from two phases 1111 (CaFeAsF) and 122 (KFe_2As_2) [2]. The high quality of the single crystal was confirmed by X-ray diffractometry and measurement of the temperature dependence of the magnetic susceptibility. The width of the superconducting transition was less than 2 K c Tc = 34 K. By high-resolution electron microscopy we have identified the defects along the ab plane. These defects are monolayers of CaFeAsF and KFe_2As_2. We were able to observe the contribution of these defects to the tunnelling current. During Andreev reflection spectroscopy experiment we have found the value of the large gap of CaFeAsF and its temperature behavior up to its local T_c (28 K) which is lies below $KCa_2Fe_4As_4F_2$ T_c (34 K). Analogously to many related compounds of iron-based superconductors [3,4], these compounds can act as additional pinning centers. Therefore, the critical current density J_c and the nature of the pinning mechanism in these samples were also examined. The magnetic hysteresis loops are highly symmetrical, which suggests bulk pinning in the sample for both orientations. The calculated critical current density is $\sim 10^6 A/cm^2$. We have found second magnetization peak (SMP) at high temperatures (near Tc), which is not in line with usual SMP position of parent compounds. When the first critical field is measured in both orientations, a significant difference in the temperature dependences of Hc1 (T) is observed.

References

[1] Z. C. Wang *et al*., *J. Am. Chem. Soc.* **138 (20)**, 7856-7859 (2016).
[2] T. Wang *et al*., *J. Phys. Chem. C.* **123 (22)**, 13925-13929 (2019).
[3] S. Ishida *et al*., *NPJ Quantum Mater.* **4**, 272019 (2019).
[3] A. Yu. Degtyarenko *et al*., *Nanomaterials* **12(21)**, 3801 (2022).