Boosting the Flux pinning properties of Fe (Se, Te) superconductors

Shengnan Zhang[1*], Jixing Liu[1], Botao Shao[1], Jianfeng Li[1], and Pingxiang Zhang[1]

[1] *Superconducting Materials Research Center, Northwest Institute for Nonferrous Metal Research, Xi'an, 710016, China*

Among the iron-based superconductors, FeSe-based compounds have attracted considerable attention due to the simplicity of crystal structure and the non-toxicity of starting materials [1]. Nevertheless, a significant discrepancy exists between the superconducting characteristics of FeSe wires/tapes and single crystals. This can be attributed to the intricate phase evolution process of the Fe-Se binary system, which involves a weak link between the grains and an excess of Fe [2-4]. Therefore, a new dual coordination effect has been adopted to solve these problems via exploring an easy and efficiency chemical elements doping.

The doping of Fe (Se, Te) superconducting bulks with halogen F and Cl was investigated. A dual-oscillation effect was proposed to explain the enhancement of flux pinning in F-doped Fe(Se,Te) samples. This effect is thought to change the hexagonal phase from a harmful phase to an effective pinning center, thereby significantly enhancing the activation energy [5]. The introduction of Cl doping results in the formation of a point-like second phase in Fe (Se, Te) which serves as a pinning center. The combined application of hydrostatic pressure and Cl doping serves to enhance the pinning ability of these point defects. As the result, the critical current density was increased up to 100 times via this dual coordination. In addition, the Ge doping of Fe (Se, Te) has also been demonstrated to exert a considerable influence on the critical current density, resulting in a notable enhancement. An accessible and effective Ag/O co-doping method was implemented for Fe(Se,Te) with the dual objective of strengthening the intergrain connection and eliminating excess Fe simultaneously. Consequently, the critical current density was markedly enhanced in both self-field and high-field conditions.

This study offers novel solutions for modulating the non-superconducting hexagonal phase, enhancing intergrain connectivity, and eliminating excess Fe in Fe(Se, Te) polycrystalline materials. These findings establish a robust foundation for the fabrication of high-performance Fe(Se, Te) superconducting wires.

References

[1] Y. Kamihara, T. Watanabe, M. Hirano, *et al.*, *J. Am. Chem. Soc* **130**, 3296-3297 (2008).

[2] R.M. Fernandes, A.I. Coldea, H. Ding, *et al.*, *Nature* **601**, 35-44 (2022).

[3] F.C. Hsu, J.Y. Luo, K.W. Yeh, *et al.*, *PNAS* **105**, 14262-4 (2008).

[4] C. Yao, Y. Ma, *iScience* **24**, 102541 (2021).

[5] J. Liu, S. Zhang, M. Li, *et al.*, *ACS APPL MATER INTER* **11**, 18825-18832 (2019).

Acknowledgment

This research was financially supported by the Key Research and Development Program of Shaanxi (No.2021KW-26) (No.2024GX-YBXM-340).

Keywords: FeSeTe, polycrystalline, flux pinning, chemical doping