Record Critical Current Density with Low Anisotropy in Highly-Textured 122 Iron-based Superconducting Tapes

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March 21, 2018 (STH55, HP130). The discovery of iron-based superconductors (IBS) in 2008[1] aroused extensive research on their practical applications and superconductivity mechanism. The K-doped 122-type IBS ($Sr_{1-x}K_xFe_2As_2$ and $Ba_{1-x}K_xFe_2As_2$) are quite attractive for high-field applications since they have a relatively high transition temperature T_c (~38 K), a high upper critical field H_{c2} (>100 T), superior transport J_c, and a very small anisotropy (1.5-2).

Since the discovery of IBS in 2008, Prof. Yanwei Ma's group from the Institute of Electrical Engineering (IEE) of the Chinese Academy of Sciences was dedicating to promoting the IBS towards applications, especially for the 122-type IBS wires and tapes using the powder-in-tube technique[2]. From the view point of practical applications, the critical current density (J_c) is a central topic of research. However, the primary obstacle of wires and tapes is the low transport J_c because of the disadvantages of polycrystalline superconductors such as the defects, impurity phase and high-angle grain boundaries. Various methods and strategies have been utilized to overcome these obstacles such as the optimization of the sintering temperature, the use of a Ag sheath to reduce the chemical reaction with IBS cores and flat rolling to induce grain texture. In 2014, Zhang *et al*. processed the as-rolled $Sr_{1-x}K_xFe_2As_2$ (Sr-122) tapes by a hot press (HP) process, which significantly improved the mass density of the superconducting core and eliminated the residual micro-cracks induced during the deformation process. They managed to enhance the transport J_c of Sr-122 tapes to the practical level of 10^5 A/cm^2 at 4.2 K and 10 T[3].

Recently, by using an optimized hot press process to achieve a higher degree of grain texture in $Ba_{1-x}K_xFe_2As_2$ (Ba-122) tapes, Prof. Ma's group further increased the transport J_c to 1.5×10^5 A/cm^2 ($I_c = 437$ A) at 4.2 K and 10 T [4]. The transport J_c measured at 4.2 K under a high magnetic field of 27 T is still on the level of 5.5×10^4 A/cm^2, as shown in Figure 1. These J_c values are the highest ever reported for iron-based superconducting wires and tapes and are also superior to NbTi, Nb_3Sn and MgB_2 tapes or wires. In addition, at 20 K and 5 T, the transport J_c achieved was as high as 5.4×10^4 A/cm^2, offering a promising application potential in a 'moderate' temperature range which can be reached by liquid hydrogen or cryogenic cooling. We further measured the transport J_c under different magnetic field directions. The J_c anisotropy of the Ba-122 tape at 10 T and 4.2 K is 1.37, a value which is much smaller than that of the Bi-2223 and YBCO tapes.

The reasons of such high transport J_c achieved in the Ba-122 tapes were systematically investigated. From the x-ray diffraction and the electron backscatter diffraction (EBSD), we find a high degree c-axis texture of the superconducting core. In the HP process, the crystal orientations of Ba-122 are prone to rotate along the tape surface by the pressure which applied to the tape surface and thus the c-axis texture is enhanced. In addition, most grains with a diameter lower than 2 μm are evenly oriented parallel to the tape surface and a large amount of low-degree misorientation angle can be detected by the EBSD. These results in this work further strengthen the position of IBS as a competitor to other superconductors in high field applications.

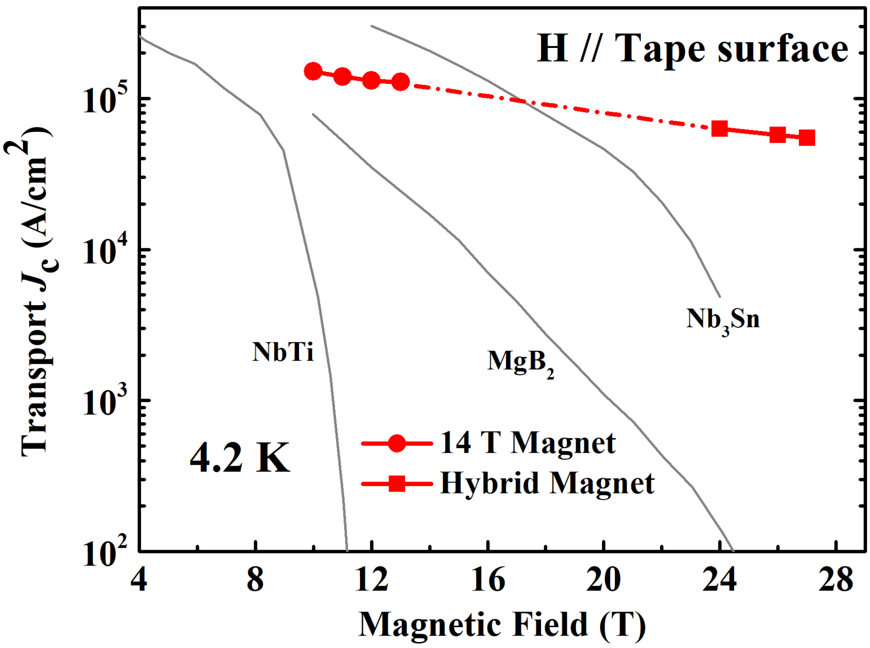

Fig. 1. Magnetic field dependence of transport J_c for the hot-pressed Ba-122 tape at 4.2 K. The transport J_c of other wires or tapes are also included for comparison.

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References

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