First Performance Test of a 30 mm Iron-based Superconducting Inserted Coil Under a 24 T Background Field

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March 28, 2019 (STH60, HP136). Since 2008, iron-based superconductors (IBS) have attracted wide interest for both basic research and practical applications. Because they have a high superconducting transition temperature (T_c), a large critical current density (J_c) over 1 MA cm^{-2} in thin films, a very high upper critical field above 100 T and a low anisotropy. After ten years of development, remarkable progress of high-performance Sr/BaKFeAs (Sr/Ba122) iron-based superconducting tape has been obtained. In 2018, the record high transport J_c value for $Ba_{1-x}K_xFe_2As_2$ (Ba122) tapes is as high as 0.15 MA/cm^2 at 4.2 K and 10 T, obtained through a hot-pressing process [1]. This suggests that IBS are quite attractive for the construction of high-field magnets needed for nuclear magnetic resonance (NMR) spectrometers, particle accelerators, fusion reactors, and also magnetic resonance imaging (MRI) systems.

For the practical application, 100 m class $Sr_{1-x}K_xFe_2As_2$ (Sr122) tapes have been fabricated in 2017 [2]. An average J_c of 1.3×10^4 A/cm^2 at 4.2 K and 10 T was reached over a 115-m length, showing good longitudinal uniformity. Besides high current carrying capacity [3], the Sr/Ba122 IBS tapes also showed a good mechanical strength [4], an excellent reversible compressive strain (> 0.6%) [5, 6], and a small anisotropy [7].

For high field applications, it's necessary to test the performance of IBS coils above 20 T. However, some main problems needed to be overcome at first, such as reaching a high performance and uniformity for long tapes, optimizing the coil winding technique as well as the coil testing technique under high fields, and so on. Recently, we firstly fabricated a 30 mm diameter iron-based superconductor single pancake coil (SPC) and successfully tested its transport properties in a 24 T background field. This SPC was successfully made by using the 7-filamentary $Ba_{1-x}K_xFe_2As_2$ (Ba122) tape produced by a wind-and-react method. This IBS coil shows the highest in-field I_c values reported so far. For example, the transport critical current of this Ba122 SPC achieved 35 A at 4.2 K and 10 T, which is about half of that for short samples. This indicates that the non-insulation winding process together with the stainless-steel tape is suitable for the iron-based superconductor. Even more encouraging is the fact that the I_c of this SPC is still as high as 26 A under 24 T background field, which is still about 40% of that at

zero external magnetic field. Meanwhile, these good results were achieved even when the coil diameter is as small as 30 mm. If the coil diameter is larger, even better properties would be expected. More details can be found in reference [8].

The high performance of the 30 mm iron-based superconducting coil under 24 T background field clearly demonstrates that the iron-based superconductors are very promising for high-field magnet applications, and it is also an important progress for the particle accelerator, fusion and MMR/MRI societies.

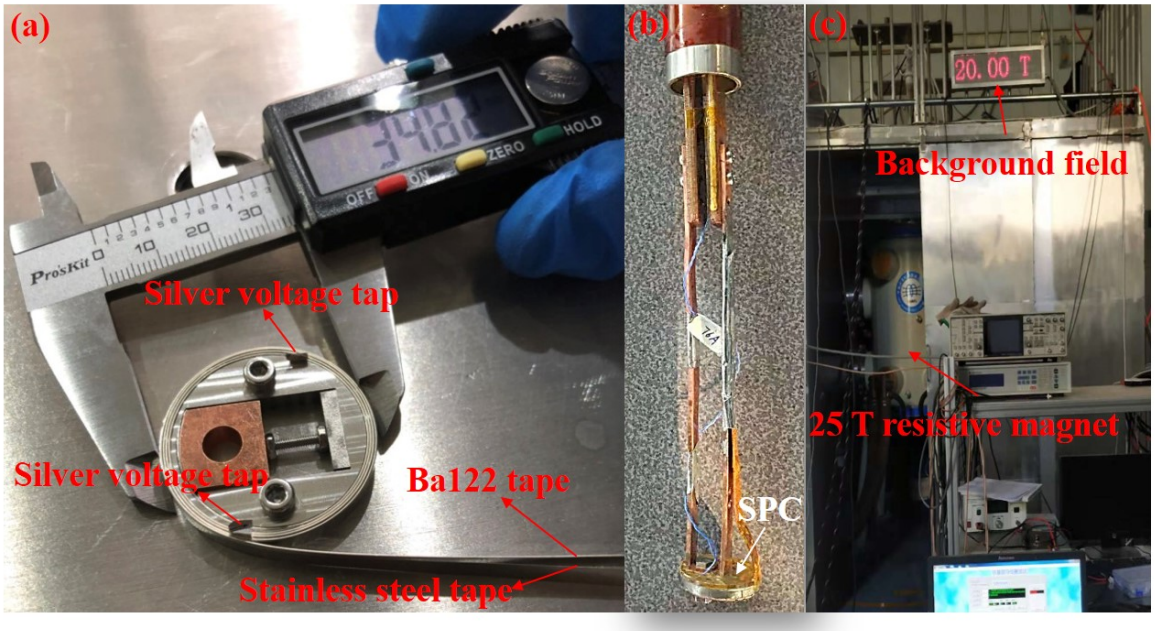

Figure 1. The outer view of Ba122 single pancake coil with 30 mm inner diameter (a), the sintered Ba122 SPC (b) and the 25 T resistive magnet (c) [8].

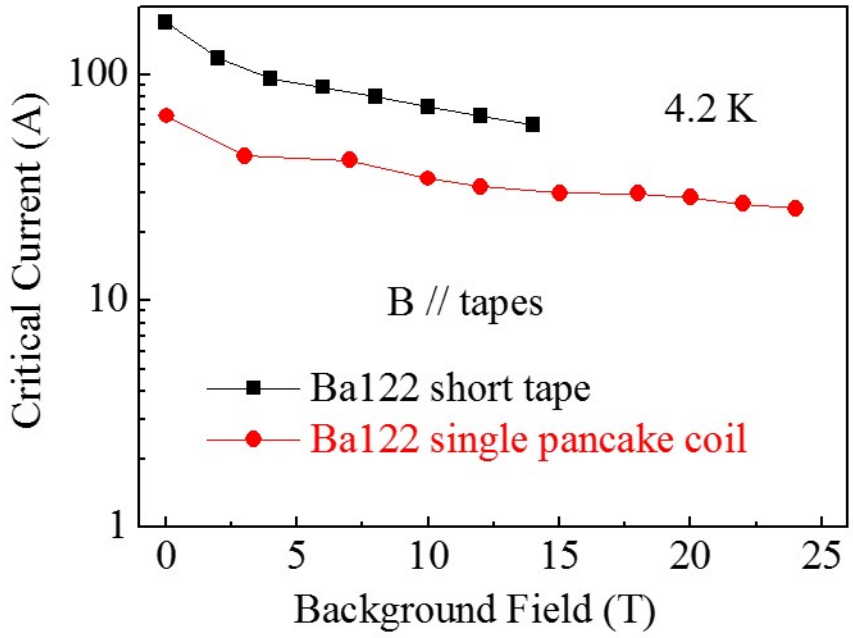

Figure 2. Magnetic field dependence of transport critical current at 4.2 K for the Ba122 straight tape and SPC [8].

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