Recent Advances in Iron-based Superconducting Wires and Tapes

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Abstract - Very recently, great progress has been made in fabricating high-performance iron-based superconducting wires. At 4.2 K, the transport critical current J_c reached 1.7×10^4 A/cm^2 at 10 T for textured powder-in-tube (PIT) $Sr_{1-x}K_xFe_2As_2$ tapes, which approaches the J_c level desired for practical applications. Furthermore, high-J_c multi-filamentary 122 type wires were successfully produced.

April 25, 2013 (STC01). The discovery of superconductivity in iron oxypnictide superconductors [1] has stimulated great interest in the fields of both superconductor applications and fundamental research. Up to now, many families of iron-based superconductors, namely, REOFeAs ("1111" type), $(Ba/Sr)_{1-x}K_xFe_2As_2$ ("122" type), LiFeAs ("111" type), FeSe("11" type) and the pnictides with perovskite-type blocking layer have been discovered. In addition to the high transition temperature, T_c, up to 55 K, the iron-based superconductors were reported to have ultrahigh upper critical fields exceeding 100 T and lower anisotropies (e.g. γ =1-2 for 122 type), suggesting their strong potential for practical applications, *e.g.*, for high-field magnets.

Shortly after the discovery of pnictides, the first attempt of wire fabrication was carried out by Ma's group in the Institute of Electrical Engineering (IEE), Chinese Academy of Sciences. Using the powder-in-tube (PIT) method, successively $LaFeAsO_{1-x}F_x$, $SmFeAsO_{1-x}F_x$ and $Sr_{1-x}K_xFe_2As_2$ wires [2-3] were prepared. At this stage, no transport current was reported although the magnetization measurement showed that the samples possess relatively high intra-granular J_c. After solving the reaction problem between the sheath material (such as Nb, Ta and Fe) and the superconducting core by employing silver tubes, critical transport current could actually be measured in the $Sr_{1-x}K_xFe_2As_2$ and $SmFeAsO_{1-x}F_x$ wires and this was the first success [4]. Transport currents of 3750 A/cm^2 in self-field and at 4.2 K were obtained for an *ex situ* PIT processed $Sr_{1-x}K_xFe_2As_2$ + Ag/Pb wire with an Fe/Ag double sheath. Now, this Ag sheathing is widely used in the fabrication of iron-based superconducting wires by other groups. Ag additions also effectively enhanced the transport J_c of $Ba_{1-x}K_xFe_2As_2$ wires as reported by NIMS [5] and University of Tokyo [6].

In order to further improve the critical current, the solution of the weak-link problem is another important issue. The IEE team was first to develop a mechanical processing strategy which allows one to obtain c-axis textured Pb-doped $Sr_{1-x}K_xFe_2As_2$

tapes with Fe sheaths by flat rolling, in order to bypass the barrier of high-misorientation-angle grain boundaries. Recently they succeeded in fabricating strongly c-axis textured Sr-122 tapes by optimizing the texturing process through Sn addition, which was an effective way to improve the grain connectivity. At 4.2 K, the J_c values showed extremely weak magnetic field dependence and reached high values of

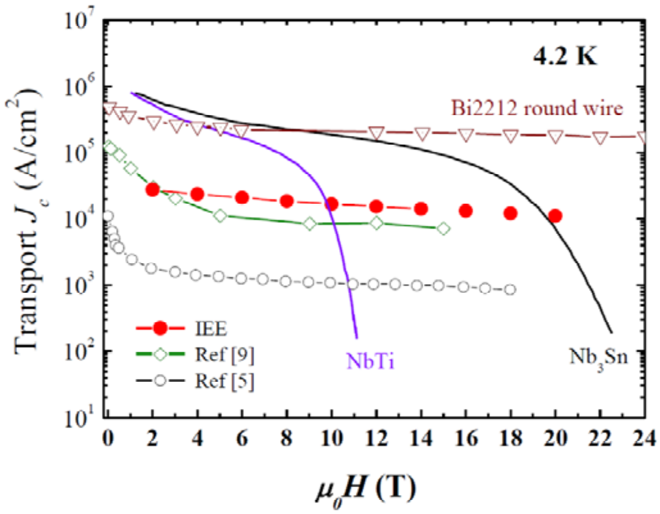

Fig. 1. Transport J_c values at 4.2 K obtained in this experiment plotted as a function of applied magnetic fields along with other reported Fe-based superconducting wires. The conventional Nb based and Bi2212 superconducting wires are also included for reference.

1.7×10^4 A/cm^2 at 10 T and 1.4×10^4 A/cm^2 at 14 T [7], respectively (see Figure 1). These values approach the J_c level desired for practical applications. It is noted that the transport J_c of the "1111" compound was also significantly increased to 2.1×10^4 A/cm^2 at 4.2 K in self field in the Sn-added *ex situ* $SmFeAsO_{1-x}F_x$ tapes [8]. By XRD and BSE-SEM analysis, it was found that the Sn additive can effectively reduce the amount of amorphous FeAs phase at the grain boundaries, thus improving the grain connectivity of the superconducting core. In addition, by using the hot isostatic pressing technique and low-temperature sintering to obtain high density and fine grains, the Florida State University achieved a transport J_c of 8.5×10^3 A/cm^2 at 4.2 K, 10 T in Cu/Ag-cladded $Ba_{1-x}K_xFe_2As_2$ wires [9].

Most recently, based on the PIT techniques used for manufacturing single-core iron pnictides wires, the IEE team successfully fabricated Ag/Fe-clad seven-core multifilamentary $Sr_{1-x}K_xFe_2As_2$ wires [10], which had a high transport J_c up to 2.1×10^4 A/cm^2 at 4.2 K, 0 T, and shows very weak field dependence at high fields.

The above results clearly demonstrated that iron-based composite wires produced using the PIT method are prospective candidates for high-field applications.

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(Editors' comment): Per our invitation, this brief overview was submitted by the authors of papers which appeared in *Appl. Phys. Lett.* **102** (2013) 082602 and *Sci. Rep.* **2** (2012) 998. We believe this progress report deserves special interest (Editors comment).