Recent advance in 122 Iron-based Superconducting Wires and Tapes: Reaching the Practical Level of Critical Current Density

Chao Yao, Xianping Zhang, He Lin, Chiheng Dong, Qianjun Zhang, Dongliang Wang and Yanwei Ma

Key Laboratory of Applied Superconductivity, Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing 100190, China: E-mail: ywma@mail.iee.ac.cn

June 20, 2014 (HP80). The K-doped 122 type $\text{AeFe}_2\text{As}_2$ ($\text{Ae}$ - alkaline earth elements) iron-pnictide superconductors are very promising in high-field applications, since they have relatively high superconducting transition temperatures ($T_c$) up to 38 K, very high upper critical fields ($H_{c2}$) above 100 T and very low superconducting anisotropy of about 1.5-2 [1]. At the end of 2012, the transport critical current density ($J_c$) of PIT processed 122 type iron-pnictide tapes made by flat rolling exceeded $10^4$ A/cm$^2$ at 4.2 K and 10 T [2], which is still one order of magnitude lower that the $J_c$ level desired for practical applications. Therefore, new processes are needed to further increase the transport $J_c$ of 122 iron-pnictide wire and tape conductors.

In 2013, we reported that uniaxial cold pressing can largely enhance the transport $J_c$ of as-drawn Sr$_{1-x}$K$_x$Fe$_2$As$_2$ (Sr-122) wires at self-field and high field [3]. However, the residual micro cracks inside the superconducting cores induced during the mechanical deformation still prevent the transport currents. Togano et al. found then that cold pressing can increase the transport $J_c$ of flat rolled Ba$_{1-x}$K$_x$Fe$_2$As$_2$ (Ba-122) tapes by densifying the superconducting core and changing the structure of cracks, which run transverse to the tape length for rolled tapes and parallel to the tape length for pressed tapes [4]. Lin et al. processed the as-rolled tapes by hot pressing combined with high-quality precursors, which significantly increased the mass density of the superconducting core, and eliminated the residual micro-cracks induced during the deformation process, thus greatly improving the transport $J_c$ of Sr-122 tapes up to $5.1\times10^4$ A/cm$^2$ (4.2 K, 10 T) [5].

Soon after that, by further optimizing the pressing process, Zhang et al. obtained highly textured Sr-122 tapes with transport $J_c$ reaching the practical level of $10^5$ A/cm$^2$ (4.2 K, 10 T) for the first time [6]. SEM observation showed that the hot pressing technique can make the grains more flexible to couple with each other without producing crashed grains, so the grain connectivity was significantly improved. Moreover, confirmed by XRD and SEM examination, the grain texture was also enhanced by hot pressing, which is beneficial to alleviate the weak-link effect at
grain boundaries. The grain boundary structure was further investigated on atomic scale using high resolution TEM, and the results showed that the Sr-122 phase inside the tapes had many clean grain boundaries with low misorientation angle. Therefore, the superior $J_c$ in these Sr-122 tapes can be attributed to the combination of improved grain connectivity, good grain texture and strong pinning characteristics.

For multifilamentary 122 iron-pnictide wires and tapes we found that hot pressing can also greatly improve their $J_c$ performance. At present, the highest $J_c$ values reached $6.1 \times 10^4$ A/cm$^2$ and $3.5 \times 10^4$ A/cm$^2$ at 4.2 K and 10 T, respectively for hot pressed 7- and 19-core Sr-122 tapes [6]. These values are the highest in multifilamentary pnictide wires at present, further demonstrating the great potential of iron-pnictide conductors for high-field applications.

![Graph](image)

**Fig. 1.** Field dependence of transport $J_c$ values at 4.2 K for hot pressed Sr-122 tapes, compared with commercial NbTi, Nb$_3$Sn and MgB$_2$ wires. The magnetic field was applied parallel to the tape surface.

**Acknowledgments**

The authors thank Dr. H. Oguro, Prof. S. Awaji and Prof. K. Watanabe at the HFLSM, Tohoku University for the high-field transport measurements.

**References**