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

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June 20, 2014 (HP80). The K-doped 122 type $AeFe_2As_2$ (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 $Sr_{1-x}K_xFe_2As_2$ (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 $Ba_{1-x}K_xFe_2As_2$ (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 5.1×10^4 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 6.1×10^4 A/cm^2 and 3.5×10^4 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.

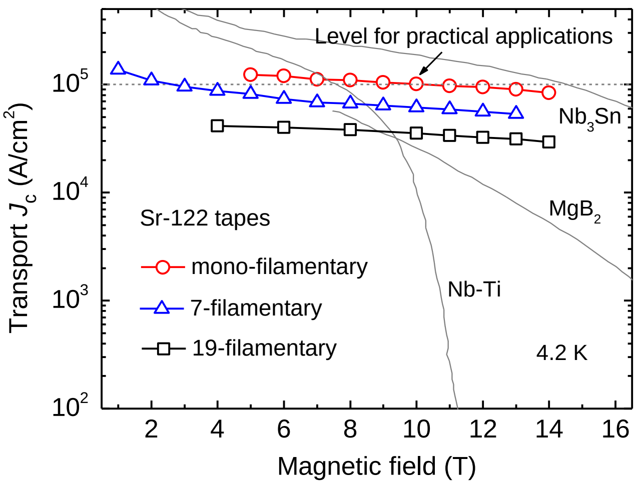

Fig. 1. Field dependence of transport J_c values at 4.2 K for hot pressed Sr-122 tapes, compared with commercial NbTi, Nb_3Sn and MgB_2 wires. The magnetic field was applied parallel to the tape surface.

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