

Microstructural engineering via grain-boundaries in Fe(Se,Te) Superconducting Films

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Superconducting technology can make smaller, lighter, and more powerful equipments that can improve power system's reliability, quality, and safety. As far as energy power applications are concerned, the stability of the superconducting state becomes relevant for the operation of these devices. Unfortunately, superconductivity becomes unstable under sufficiently high bias currents. Not only the highest critical currents are required but also quenching phenomena need to be prevented to get the best performance of any superconducting device. Here we analyse material pinning anisotropy in an Iron-Based Superconductor (IBS) competitor of High Temperature Superconductors (HTS), since anisotropy is also a key ingredient for high-field magnet applications. We follow an approach based on electric transport measurements as a function of temperature, magnetic field intensity and orientation that is suitable for any superconducting material. Here we present results from experiments on two exemplary superconductors relevant for applications: the very weak anisotropic IBS- Fe(Se,Te) and the layered anisotropic HTS-YBCO Superconductor, both known as three-dimensional superconductors. Both materials show the same anisotropic behaviour in the range from 90% (upper critical field) to 50% (medium-point field) of normal state resistance, but not at 10% (irreversibility field). TEM microstructure analysis provides direct evidence that the observed anisotropic pinning behaviour originates from the specific arrangement of grain-boundary defects in these IBS-Fe(Se,Te) films grown on CaF₂ substrate by PLD. In fact, the "Lego-block" growth structure provides effective, quasi-isotropic pinning centers, consistent with the angular behaviour observed in the irreversibility field. We demonstrate that the IBS-Fe(Se,Te) film not only is able to mimic the layered structure of HTS-YBCO film but also offers a pathway to engineering isotropic superconductors via grain-boundaries pinning.

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