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The Superconducting Conductor Challenge

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The dominant use of superconductors remains magnet technology, applications very well served by the low temperature superconductors (LTS), Nb-Ti and Nb3Sn, even if the dreams of large scale superconducting electrotechnology have driven huge investments in the High Temperature Superconductor (HTS) conductors, (Bi,Pb)2Sr2Ca2Cu3O10 (Bi-2223) and REBa2Cu3Ox (REBCO). But well over 95% of all superconductors are LTS round wires, while Bi-2223 and REBCO are both high aspect ratio tapes. Their potential for service well above liquid helium temperatures continues to drive their development, yet their constrained architectures and high costs pose continued challenges. Thus MgB2 with Tc of 38 K, a medium temperature superconductor (MTS) also challenges HTS applications, both because of its inexpensive raw materials and because of its round, multifilament form. But it does not yet really challenge LTS applications, because its high Tc does not compensate a low critical field. However the MTS compound (Ba0.6K0.4)Fe2As2 (K-122) is potentially capable of challenging LTS, because it is also fabricated from comparatively cheap raw materials and it has 5 times the upper critical field of MgB2 (>80 T at 4 K) and 3 times that of Nb3Sn. But Bi-2223 and REBCO suffer from weak superconducting grain boundaries (GBs) that force their fabrication with extreme crystallographic texture so as to minimize their GB density. But this old paradigm may be changing: The largely ignored Bi2Sr2CaCu2O8+x (Bi-2212) has evolved into a round, multifilament, twisted conductor with flexible architecture that has the highest Jc (at 4 K, anyway) of any HTS conductor. And K-122 in untextured, high GB density form has Jc within about a factor of 5 of that needed for applications. Thus superconducting conductor technology is at a very interesting stage: Bi-2212 and MgB2 will allow magnets in domains of H and T inaccessible to LTS conductors in the same round, multifilament, twisted architecture that magnet builders really prefer. Most intriguingly of all is the prospect of an equivalent REBCO round wire technology if only the better GB transparency now being exhibited in Bi-2212 and K-122 could be developed in REBCO too. Such a conductor could take superconducting magnet technology into totally new domains, both for small lab and for large machine magnets like those needed for DEMO or High Energy Hadron colliders. My talk will review recent progress and the nature of the challenges for new conductor technologies.

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