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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 REBa₂Cu₃O_x (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 T_c 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 T_c does not compensate a low critical field. However the MTS compound (Ba_{0.6}K_{0.4})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 Bi₂Sr₂CaCu₂O_{8+x} (Bi-2212) has evolved into a round, multifilament, twisted conductor with flexible architecture that has the highest J_c (at 4 K, anyway) of any HTS conductor. And K-122 in untextured, high GB density form has J_c 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.

Author: LARBALESTIER, David (National High Magnetic Field Laboratory)

Presenter: LARBALESTIER, David (National High Magnetic Field Laboratory)

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