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Superconductivity at 100 - what materials will serve us in the next century?

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Superconductivity continues to fascinate both at the fundamental mechanism level and for its potential for applications. In fact Onnes came to Chicago in 1913, just two years after discovering superconductivity, with a detailed plan to make a 10 T superconducting magnet! At the centenary it may be worth reflecting on what of Onnes' vision has worked and what, so far anyway, has not worked. In the achievement column we can put large numbers of superconducting magnets made of Nb-Ti and Nb_3Sn, cooled largely by liquid helium and generating fields above 23 T. Such magnets underpin the large MRI industry (1.5-3T), high field NMR (10-23T), and large accelerators like the LHC (up to 8.5T). Both Nb-Ti and Nb_3Sn are well developed conductor materials, now working close to their intrinsic limits and thus not normally discussed at the MRS, where much greater interest is shown in the cuprate high temperature superconductors. The basis of interest is for electric utility applications in temperature and field domains far from the liquid helium range accessible with Nb-base materials. Extraordinary efforts to master these complex materials have been made and great technical successes achieved. And yet, access to the expected markets has proven much harder than expected, to the point that new discoveries like MgB2, potentially much cheaper but with much less cryogenic advantage, and pnictides with higher Tc than MgB_2 but lesser T_c than the cuprates, even though with much lower anisotropy, sometimes make their claims against cuprates like YBCO. And now too, new programs to discover much higher T_c, perhaps even at room temperature, are underway. Clearly many want new conductor materials with much higher T_c and H_{c2} than the isotropic Nb-base materials. Yet dealing with the anisotropy and the poor grain boundary transport of pnictides and cuprates poses tough manufacturing challenges, problems unlikely to be any less significant with new materials. How to develop appropriate strategies for dealing with these complexities will be a major them of my talk.