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Development of superconductors for future large scale applications

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Particle accelerators have been an important driver of superconductor development, and Nb-Ti technology has enabled, in the last thirty years, fundamental discoveries in high energy physics. While the Large Hadron Collider continues delivering data and investigating the experimentally achievable domain, the quest for new subnuclear phenomena, beyond the Standard Model, has generated studies on future 100 TeV-scale synchrotron machines based magnets capable of delivering fields of 16 to 20 T. Nb3Sn is to date the baseline superconducting technology of the Future Circular Collider (FCC). A key technological challenge of the FCC study is the R&D aimed at exceeding present state-of-the-art performance in a cost effective Nb3Sn superconductor, and a world-wide effort on conductor development has recently been launched by CERN. In the last decade, the landscape of superconducting materials showing potential for accelerator technology has significantly enlarged. Nb3Sn will be used in the High Luminosity LHC (HL-LHC) upgrade; REBCO conductors, with superior performance, have become commercially available from several companies; BSCCO 2212 has demonstrated in-field capability; on a longer term perspective, encouraging fundamental properties of MgB2 and iron-based materials motivate studies for understanding and improving their in-field characteristics. For electrical transmission, LHC and HL-LHC rely respectively on BSCCO 2223 and MgB2. The challenges and potential of both low-temperature (LTS) and hightemperature superconductors (HTS) are presented, with close attention being paid to the requirements driven by future high energy accelerators. Considerations on targets of performance and cost of Nb3Sn and HTS superconductors, which could enable their adoption in large scale applications, are discussed.

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