Advances in MgB_2 Conductors

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Abstract — The compound MgB_2 (T_c = 39K) occupies an intermediate position between LTS and HTS superconductors. It is a two-band superconductor with a complex, non-BCS behavior of the anisotropic properties as a function of magnetic field and temperature. On the other hand, some properties can be described by a conventional phonon-mediated mechanism of superconductivity.
The application range of this material is restricted by its low irreversibility field, which does not exceed 25T, even in wires with carbon additives. However, for intermediate fields and T ≤ 25K this disadvantage with respect to HTS materials is compensated by production costs being more than one order of magnitude lower (< 3$/kAm): for selected applications, MgB_2 appears thus increasingly as an alternative solution to HTS materials.

Various powder metallurgical approaches are known for the fabrication of multifilamentary MgB_2 wires up to lengths beyond 10 km. It has been found that the optimization of J_c in wires requires nanosize powders (this holds particularly for B as well as for carbon dopants). An additional requirement is a high mass density in the filaments, leading to enhanced grain connectivity. The presently applied processing techniques are reviewed.

The first industrial application of MgB_2 was the production of open-sky MRI magnets operating at 20K. The great potential of this material for the transmission of electrical power has been recently demonstrated at CERN, where a 20 meter MgB_2 cable carrying 20 kA in He gas at 24K was successfully tested in view of current leads for the High-Luminosity LHC project. Future projects will also include LH2 cooled MgB_2 cables: a first MgB_2 cable carrying 3 kA at 20K has already been successfully tested in Moscow. Recently, a new hybrid energy storage concept, has been proposed at Nihon University (J), which combines the use of liquid hydrogen as the bulk energy carrier with superconducting magnetic energy storage (SMES). With the expected increase of the share of renewable power in the energy mix, efficient long distance electricity transport infrastructure has become a strategic priority: MgB_2 cables as an alternative to standard HVDC (High Voltage Direct Current) power lines are under study. Finally, calculations have shown that MgB_2 would be the most cost-effective option in view of large rotating machines, e.g. wind turbine generators at ≥ 5 MW. Cost-efficiency is the driving force behind the future applications of MgB_2, which will be briefly presented.

Keywords (Index Terms) — MgB_2 superconductors, MgB_2 wire processing techniques, MRI magnets, current cables, He gas and liquid hydrogen cooling, SMES for renewable power control, power conditioning systems, persistent mode magnets for levitation.