Development of MgB_2 composites by spark plasma sintering as a superconductor and as a novel material for biomedical applications

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MgB_2 is prized as a superconducting material. It has advantages over low (LTS) and high temperature (HTS) superconductors: MgB_2 is a light-weight material, it is a simple compound, it is available, it has a low price, and it has the highest critical temperature T_c for the binary superconductors (39K). The coherence length of MgB_2 is relatively large if compared with the values for HTS. The consequences are that for the enhancement of the critical current density J_c, epitaxial samples with low angle boundaries and their expensive fabrication technologies as for HTS are not necessary in the case of MgB_2. Moreover, in MgB_2 grain boundaries are recognized to be transparent to the super-current-flow and they play the role of efficient pinning centers, enhancing J_c. Grain boundaries can be modified by introducing additions which are not substituting in the crystal lattice of MgB_2 and by processing. Substitutions into the crystal lattice of MgB_2 are also of interest for the improvement of the superconducting parameters.

In our work we use the *ex-situ* spark plasma sintering (SPS). Samples are mixtures of MgB_2 and additive powders. During SPS a uniaxial pressure and a pulsed current are applied on the mold system containing the powder mixture. Although still under debate, between the particles of the powder, unconventional activation processes may occur, accelerating consolidation processes and modifying the grain boundaries. The bulk density of our MgB_2 samples is above 90%. The following additives classified into 4 groups were tested: (1)- approximately inert such as c-BN, h-BN and graphene, (2)- reactive with formation of M_yB_z such as RE_2O_3, RE = La, Eu, Ho, (3)- reactive with formation of Mg_uM_v such as Sb, Bi, Te and their oxides, and (4)- additives which are source of carbon substituting for boron in the crystal lattice of MgB_2 such as fullerene (F), F + c-BN, SiC, B_4C, SiC + Te and $Ge_2H_{10}C_6O_7$. Some additives such as Te, $Ge_2H_{10}C_6O_7$ or c-BN significantly increase J_c and the irreversibility field H_{irr}, while suppression of J_c at low magnetic fields is minimized (Fig. 1).

Recently, we have proposed MgB_2 composites added with RE_2O_3 as a new material for biomedical applications. We paid attention to biodegradation and corrosion aspects as well as to *in-vitro* biocompatibility and antibacterial activity against Escherichia coli, and Staphylococcus aureus. Results suggest that MgB_2-based materials deserve attention for implants or sterile medical instruments.

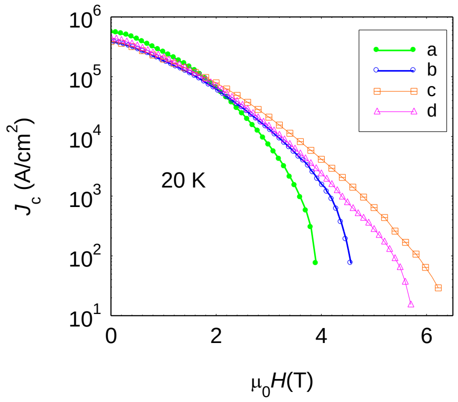

Fig. 1 J_c-H curves for samples: a-MgB_2; b-$MgB_2(Te)_{0.01}$, c-$MgB_2(Ge_2C_6H_{10}O_7)_{0.0014}$; d-$MgB_2(c\text{-}BN)_{0.01}$.