Study of transport properties of HTSC based Josephson junctions network with magneto–active barriers

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The aim of this work is to study the effect of magnetic moments in insulator barriers between High Temperature Superconductors (HTSCs) on tunneling of current carriers. Bulk composites HTSC + magneto–active insulator with volume content of the latter component 7.5% and 15% representing a network of Superconductor–Insulator–Superconductor Josephson junctions have been prepared. Paramagnetic $NiTiO_3$ and ferrimagnetic $Y_3Fe_5O_{12}$ have been used as materials forming magneto–active barriers between HTSC crystallites. ˆNonmagnetic˜ $MgTiO_3$ and $Y_3Al_5O_{12}$ respectively have been used as materials for the ˆbench mark˜ composite samples in order to emphasize the effect of magnetic moments of the barriers on the transport properties of the composites. The temperature dependences of resistivity R(T) at different applied magnetic fields H, the temperature dependences critical current density $J_C(T)$, and the current–voltage characteristics (CVCs) at different temperatures are presented. The R(T) dependences of composites $Y_{3/4}Lu_{1/4}Ba_2Cu_3O_7$ + $MgTiO_3$ are fitted well by the mechanism of Thermally Activated Phase Slippage (TAPS) in Josephson junction using assumption of potential barrier of varying length. The anomalous behavior of R(T) of composites $Y_{3/4}Lu_{1/4}Ba_2Cu_3O_7$ + paramagnetic $NiTiO_3$, manifesting as a kink on R(T) curves at some temperature Tm » 76K has been observed. In the temperature range $T_m < T < T_C$ the CVC are linears, resistivity weakly depends on H, while below Tm the CVCs are non–linear and strong dependence of R(H) takes place. Anomalous behavior of composites HTSC + $NiTiO_3$ is explained by the effect of magnetic moments of Ni in insulating barriers between HTSC crystallites on the transport of current carriers. The peculiarity observed is interpreted as arisen owing to Abrikosov vortices flow. For the composites $Y_{3/4}Lu_{1/4}Ba_2Cu_3O_7$ + $Y_3Fe_5O_{12}$ similar picture of R(T,H) has been observed. Temperature Tm equals to ~ 40 K. Composites $Y_{3/4}Lu_{1/4}Ba_2Cu_3O_7$ + $Y_3Al_5O_{12}$ demonstrates R(T,H) behavior similar to that predicted by mechanism of TAPS. Magnetic properties of the composites also have been measured. The magnetization curves of $Y_{3/4}Lu_{1/4}Ba_2Cu_3O_7$ + $Y_3Fe_5O_{12}$ composites represents the superposition of ferrimagnetic and superconducting hysteresis loops. There is a knee on the $J_C(T)$ of composite sample $Y_{3/4}Lu_{1/4}Ba_2Cu_3O_7$ + $NiTiO_3$ correlating with Neel temperature of antiferromagnetic $NiTiO_3$. The knee on the $J_C(T)$ of composite sample $Y_{3/4}Lu_{1/4}Ba_2Cu_3O_7$ + $NiTiO_3$ at Neel temperature of antiferromagnetic $NiTiO_3$ (T_N~22K) is observed. This peculiarity can be explained by sharp decreasing of antiferromagnetic correlation length at Neel temperature, so below T_N the additional mechanism of reduction of superconducting properties takes place. Thus, the although transport properties of Josephson networks including paramagnetic and ferrimagnetic barriers are quality similar the magnitude of effects (T_m, $T_C(R=0)$, $J_C(T)$) is quite different.