Anisotropy of Li, Al, and C substituted MgB_2 single crystals studied by thermopower

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In this work we examine the temperature dependence of the in-plane (S_{ab}) and out-of-plane (S_c) thermopower of MgB_2 single crystals doped with holes and electrons by the partial substitution of Li, Al, and C. The thermopower anisotropy has been defined as $\gamma_S = |S_{ab}-S_c|/|S_c|$, where in the denominator is a lower value of $|S_x|$. For unsubstituted crystals, S_{ab} = 12 μV/K, S_c = 3 μV/K and thus γ_S = 3 have been determined at room temperature. Substitution of Li for Mg, which dopes MgB_2 with holes, results in a moderate decrease of both S_{ab} and S_c without any influence on γ_S. Substitution of Al for Mg, which dopes MgB_2 with electrons and lowers both the π-band and the σ-band energy gaps, decreases S_{ab} and S_c with a larger rate ΔS/%Al than ΔS/%Li, however γ_S remains also unchanged, even for heavier doped crystals (16% of Al, T_c = 28 K). Substitution of C for B, which dopes MgB_2 with electrons and lowers mostly the σ-band energy gap, decreases both S_{ab} and S_c much more effectively and in addition reduces substantially γ_S. At room temperature the thermopower lowers to S_{ab} = -1 μV/K and S_c = -3 μV/K, for a crystal with 10% of C (T_c = 29 K), what results in γ_S = 2. The relatively large reduction of the thermopower anisotropy for the C-substituted MgB_2 suggests that all electronic-structure-related anisotropies may also reduce and this consequence seems to be important for applications.