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Influence of Al doping on the superconducting properties of magnesium diboride single crystals

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We present a systematic study of the evolution of the lower (H_{c1}) and upper (H_{c2}) critical fields, gap values and Sommerfeld coefficient of $Mg_{1-x}Al_xB_2$ single crystals (for $x = 0$, 0.1 and ≥ 0.2). We show that H_{c1} and H_{c2} deduced from Hall probe magnetization and specific heat measurements, respectively are both decreasing with increasing doping content. The corresponding anisotropy parameter $\Gamma_{H_{c2}}(0) = H^{ab}_{c2}(0)/H^{c}_{c2}(0)$ value also decreases from ~ 5 in pure MgB_2 samples down to ~ 1.5 for $x \geq 0.2$ whereas $\Gamma_{H_{c1}}(0) = H^{c}_{c1}(0)/H^{ab}_{c1}(0)$ remains on the order of 1 in all samples. The magnetic field dependence of the anisotropy parameter $\Gamma_{H_{c1}} \leq \Gamma(H) \leq \Gamma_{H_{c2}}$ has then been deduced from a detailled analysis of the angular dependence of the Sommerfeld coefficient for different values of the applied fields. The small and large gap values have been obtained both by fitting the temperature dependence of the zero field electronic contribution to the specific heat to the two gap model and by point contact spectroscopy measurements. Both measurements led to very similar values and the evolution of those gaps with Al concentration suggests that both band filling and interband scattering effects are present.
This work has been performed in collaboration with : L.Lyard, C.Marcenat, J.Marcus, Z.Holanova, P.Szabo, P.Samuely, B.W.Kang, H-J.Kim, H-S.Lee, H-K.Lee,S-I.Lee, S.Tajima and S.Lee.