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Scattering in MgB_2 produced by substitutions and damage

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The two-gap nature of superconductivity is a unique feature of MgB_2that stimulates many theoretical and experimental investigations. From the beginning it was pointed out that the peculiar role of disorder in a two-gap superconductor In fact, inter-band scattering by non-magnetic impurities is expected to suppresses the critical temperature T_c down to 20 K, where an equivalent one-gap BCS system stabilizes. The verification of these predictions has motivated several efforts to introduce defects in MgB_2 by substitutions (Al in sites of Mg and C in sites of B) and by irradiation. Substitutions modify electronic structure so that superconductivity can be influenced. To overcome this problem we studied two different kind of samples: co-doped $Mg_{1-x}(AlLi)_xB_2$ in which the disorder induced by the Mg substitution is accompanied by a rather complete charge compensation, and neutron irradiated $Mg^{11}B_2$. In both the sample series remarkable changes in the band structure are not expected. The superconducting properties of $Mg_{1-x}(AlLi)_xB_2$are compared with those of $Mg_{1-x}Al_xB_2$. All the properties scale systematically as a function of the Al content rather than electron doping. This suggests that the lattice deformations induced by Al, namely point-like defects and lattice compression, are very effective in tuning the superconducting properties. Similar conclusion can be drawn by the study of neutron irradiated samples. By increasing the neutron fluence, T_c monotonously decreases down to 9 K, the resistivity raises by two order of magnitude and the cell volume increases (1.7%). Our results demonstrate that the critical temperature is suppressed by the disorder well down the value of 20 K. On the other hand, the two-gap feature evident in the temperature range above 21 K, disappears when T_c is lowered down to 11 and 8.7 K a single-gap superconductivity is established.