

Magnetic and non-magnetic substitutions in MgB_2 single crystals

Roman Puźniak¹

¹*Institute of Physics of the Polish Academy of Sciences,
Aleja Lotnikow 32-46, PL-02668 Warsaw, Poland*

Many efforts have been devoted to the study of the chemical substitutions of MgB_2 , focusing on understanding the nature of the parent compound. However, until now, only the substitution of Al for Mg and C for B has been possible at relatively high doping levels [1]. Other substitutions for $\text{Mg}_{1-x}\text{M}_x\text{B}_2$, such as $M = \text{Ti, Zr, Mo, Mn, Fe, Ca, Ag, Cu, Y, La, Dy, Ho, Nd, etc.}$, are restricted to a very low concentration. Among the attempted transition-metal substitutions, that with Fe is rather unique. The variation of the critical temperature T_c in $\text{Mg}_{1-x}\text{Fe}_x\text{B}_2$ crystals was found to be different from that observed in polycrystalline samples. For a small Fe doping, up to $x \leq 0.03$, the behavior of $T_c(x)$ is similar to that for the crystals with Al and C substitutions. In this doping range, measurements of the temperature-dependent magnetization performed in high magnetic fields exclude spin states other than $S = 0$ for the Fe ions. However, for $x \geq 0.03$, certain crystals start to show a dramatic decrease in T_c . The M - H dependence for these crystals indicates a significant increase in magnetization as the magnetic field increases at low field strengths, suggesting weak ferromagnetism [2]. It was concluded that superconductivity in MgB_2 is destroyed by magnetic substitutions.

References:

- [1] J. Karpinski, N. D. Zhigadlo, S. Katrych, R. Puzniak, K. Rogacki, R. Gonnelli, Single crystals of MgB_2 : Synthesis, substitutions and properties, *Physica C* **456** (2007) 3–13, <https://doi.org/10.1016/j.physc.2007.01.031>.
- [2] N. D. Zhigadlo, R. Puzniak, High-pressure high-temperature solution growth, structural, and superconducting properties of Fe-substituted MgB_2 single crystals, *J. Cryst. Growth* **667** (2025) 128244, <https://doi.org/10.1016/j.jcrysgro.2025.128244>