Temperature dependant heterogeneous magnetic properties in Cr-Fe-Mn alloys

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This study focuses on $Cr_{74}Fe_{21}Mn_5$ and $Cr_{83}Fe_{14}Mn_3$ alloys prepared by arc-melting. The actual concentrations of the individual elements were verified using electron microprobe analyses within an error of ± (3%, 2%, 0.5%) for Cr, Fe, Mn, respectively, in both alloys. ZFC and FC magnetization show that both alloys change from a paramagnetic phase at high temperatures to a spin-glass state at low temperatures signalled by a sharp downturn in the ZFC data. Temperature dependant hysteresis shows that the alloys become ferromagnetic below 100 K. Further analysis of the magnetization reveals that there exist intermediate competing antiferromagnetic and ferromagnetic phases resulting in heterogeneous magnetic states in the system [1]. The magnetic ordering is sensitive to the Fe content where both alloys exhibit deviation from the Curie-Weiss behavior, with a positive Curie constant, indicating a ferromagnetic exchange interaction. The alloys re-enter into a disordered phase, suggesting that the ferromagnetism and the re-entrant spin-glass phase arise because of the presence of Fe in an antiferromagnetic Cr-Mn matrix. The Curie temperature (T_C) (97 and 70 ±5K), Néel temperature (T_N) (249 and 174 ±5K), spin glass transition temperature (T_g) (8 and 7 ±1 K), and Curie constant (θ) (215 and 130 ±1K) for $Cr_{74}Fe_{21}Mn_5$ and $Cr_{83}Fe_{14}Mn_5$, respectively, are derived from the magnetization studies. These findings show that these magnetic phase transitions are connected to spontaneous symmetry breaking and the appearance of discontinuities in the physical properties of the system [2,3].

References:

[1] Ch. Somsen et.al. J. Magn. Magn. Mater, Vol. 208. 191, (2000).
[2] X.Hai et.al. J. Solid State Chem, 277. 680, (2019).
[3] R Bijker. Phase transitions and spontaneously broken symmetries. Fundamentals of Physics, (2009).

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