Magnetic Properties of Highly Pure $(Cr_{1-x}Mn_x)_2AlC$ MAX-Phase

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MAX-phases are the family of layered ternary compounds, with the common $M_{n+1}AX_n$ chemistry, where M is an early transition metal, A is an A-group element (mostly IIIA and IVA) and X is either C or N. MAX-phases possess the unique set of physical characteristics, combining metallic and ceramic ones which are high values of thermal and electrical conductivity, great oxidation resistance, easy machinability, tolerance to thermal shock and mechanical damages [1]. The major part of MAX-phases is paramagnetic, although the Cr_2AlC compound was anticipated to be an antiferromagnet [2]. Doping of Cr_2AlC MAX-phase with manganese on Cr-site was proposed to enhance the net magnetic moment of the compound [3]. However, due to the closeness of ferromagnetic (FM) and antiferromagnetic (AFM) states on an energy scale [4] and the poor quality of samples [5] it is still an actual goal to analyze the magnetic nature of $(Cr_{1-x}Mn_x)_2AlC$ MAX-phase.

Samples of $(Cr_{1-x}Mn_x)_2AlC$ MAX-phase with x = 0, 0.025, 0.05 and 0.1 were synthesized using the arc melting technique and characterized by means of XRD and SEM-EDX analysis. Magnetometry measurements were performed using SQUID and the vibrating sample magnetometer. Magnetization (M) *versus* temperature (T) and magnetic field (H) dependences were obtained in the range of T from 2 K to 350 K and H from zero to 7 T. When the fascinating feature of the canted AFM behavior was revealed by SQUID-magnetometry, the complex optimization procedure of the arc melting technique was performed to produce the highly pure phase of $(Cr_{1-x}Mn_x)_2AlC$. XRD and SEM-EDX analysis revealed the high quality of samples and the uniform distribution of Mn. Magnetic properties measurements showed the designated competition of FM and AFM interactions. These results provided deeper insight into the understanding of the magnetic nature of Cr-based MAX-phases and may be used for the further application-oriented investigations.

References

[1] - M. W. Barsoum, Progress in Solid State Chemistry **28(1-4)**, p. 201-281 (2000).
[2] - J. M. Schneider, Z. Sun, R. Mertens, F. Uestel, R. Ahuja, Solid State Communications **130**, p. 445-449 (2004).
[3] - M. Dahlqvist, B. Alling, I. A. Abrikosov and J. Rosen, Physical Review B **84(2)**, 220403 (2011).
[4] - M. Dahlqvist, B. Alling and J. Rosen, Journal of Physics: Condensed Matter **27(9)**, 095601(8pp) (2015).
[5] - C. M. Hamm, J. D. Bocarsly, G. Seward, U. I. Kramm and C. S. Birkel, Journal of Materials Chemistry C **23(5)**, p. 5700-5708 (2017).