Influence of Cr-substitution on the magnetic properties of $Fe_{1-x}Cr_xSnSbO_6$

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The oxides SnO_2, Fe_2O_3, Cr_2O_3 and Sb_2O_4 and known compounds formed with the participation of these oxides, due to their chemical, magnetic, electrical and catalytic properties are particularly attractive for basic research and for a large number of prospective applications. A new continuous substitution solid solution of a $Fe_{1-x}Cr_xSnSbO_6$ type is formed in the $FeSnSbO_6$–$CrSnSbO_6$ system and crystallize in the tetragonal system and they have the rutile-type structure [1,2]. The ultraviolet-visible and near-infrared measurements showed that the energy gap, E_g, in $Fe_{1-x}Cr_xSnSbO_6$ increases monotonically with increasing content x, *i.e.* E_g = 1.67, 1.88, 1.89, 1.96 and 2.01 eV for x = 0.0, 0.25, 0.5, 0.75 and 1.0, respectively [3]. Electrical measurements of $Fe_{1-x}Cr_xSnSbO_6$ solid solution showed semiconducting behaviour with the activation energy decreasing from E_A = 0.64 eV for x = 0.0 to E_A = 0.32 eV for x = 1.0 in the intrinsic conductivity temperature region as well as the *n*-type conduction at room temperature. The *I-V* characteristics and the conductance *G* at 300 and 400 K showed symmetrical and non-linear behavior in the voltage range (-100, 100 V) suggesting the electron emission over the potential barrier especially for the boundary compounds $FeSnSbO_6$ and $CrSnSbO_6$ [4].

Magnetization measurements were carried out using a Quantum Design System (MPMS XL). Static (dc) magnetic susceptibility was measured in the magnetic field H_{dc} = 1000 Oe and recorded both in zero-field-cooled (ZFC) and field-cooled (FC) mode. Dynamic (ac) magnetic susceptibility was measured at an internal oscillating magnetic field H_{ac} = 3.9 Oe with an internal frequency f = 300 Hz. Both dc and ac magnetic susceptibility were measured in the temperature range 2–300 K. Magnetization isotherms were measured in the temperature range 2-300 K in static (dc) magnetic fields up to 70 kOe.

Magnetic measurements showed that the $Fe_{1-x}Cr_xSnSbO_6$ solid solution is ferrimagnetic over the range of concentrations of chromium ions from x = 0.0 to x = 1.0. Only for x = 1.0 the long-range ferrimagnetic interaction with the Curie temperature T_C = 5 K is observed. In all samples, a short-range antiferromagnetic interaction occurred, seen in a negative paramagnetic Curie-Weiss temperature that varied from -41 K for x = 0.0 via -157 K for x = 0.5 to -190 K for x = 1.0. The effective magnetic moment increased from 3.585 μ_B/f.u. for x = 0.0 to 4.99 μ_B/f.u. for x = 1.0, suggesting the existence of both a mixed valence chromium and iron ions. The imaginary component of ac magnetic susceptibility showed the oscillating values close to zero, indicating a lack of the energy dissipation characteristic for the ferrimagnetic state and spin frustration. The most interesting observation was the appearance of the spin-glass-state with an increase in the content of chromium ions, for which the freezing temperature reached the highest value of 25 K for x = 1.0.

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