Magnetic and structural features of $Sr_2FeMoO_{6-\delta}$ (SFMO) double perovskite near Curie temperature

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Introduction:

The Sr_2FeMoO_6 (SFMO) metal-oxide compound is known as prospective one for spintronics applications with additional advantages such as high values of the Curie temperature, large magnetoresistance, high sensitivity to the magnitude and orientation of the magnetic field, good temperature and chemical stability. Here, $Sr_2FeMoO_{6-\delta}$ polycrystalline nanocomposite samples with different oxygen content were synthesized by the solid-phase technique to study the influence of oxygen on formation of their crystalline structure and magnetic ordering.

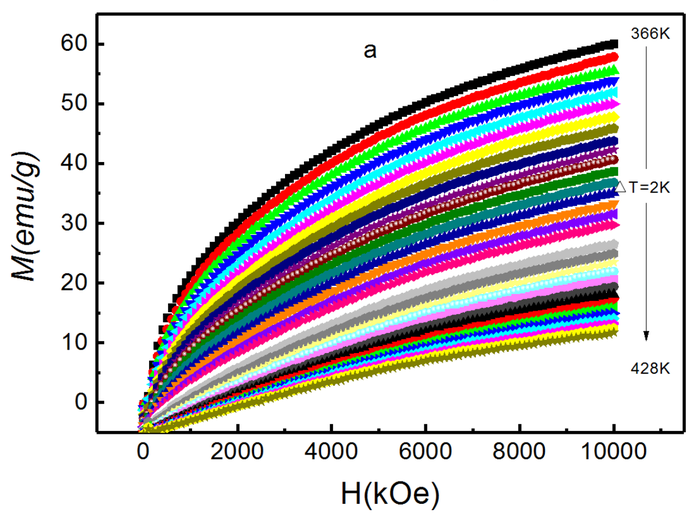
Methods:

$$MoO_3 + Fe_2O_3 + SrCO_3 \rightarrow SrFeO_{2.52} + SrMoO_4 \rightarrow Sr_2FeMoO_{6-\delta}$$

$Sr_2FeMoO_{6-\delta}$ with various δ and P parameters were obtained by annealing at 1420 K in the stream of 5%H_2/Ar gas mixture during 20 h **(sample *A*–1, $Sr_2FeMoO_{5.97}$, P = 76%)**, 50 h **(*A*–2, $Sr_2FeMoO_{5.94}$, P = 86%)** and 90 h **(*A*–3, $Sr_2FeMoO_{5.94}$, P = 93%)**, where P is the degree of iron and molybdenum cations superstructructural ordering

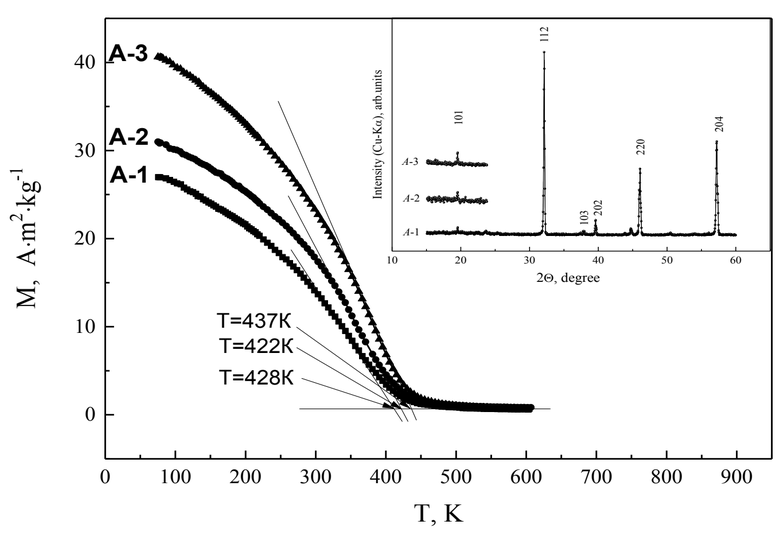
Results:

Figure 2. Isotherms of A—3 magnetization measured at temperatures of 366-428 K



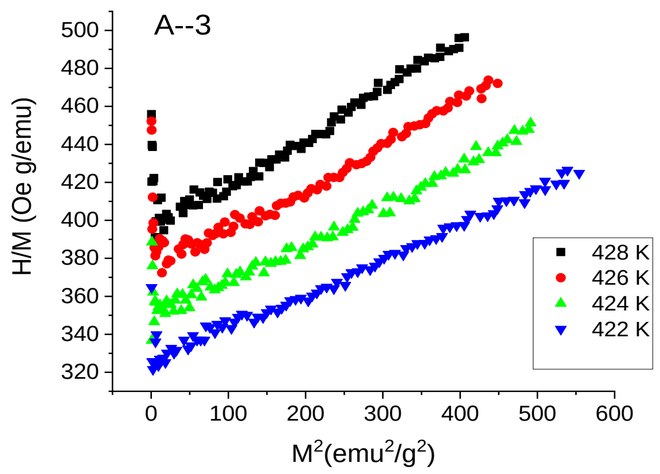
Magnetization shows a sharp drop with T, which is attributed to phase transition. The temperatures of phase transitions T_C for all samples were determined as extrapolations down to zero the tangent lines at the temperatures where the derivative is maximum

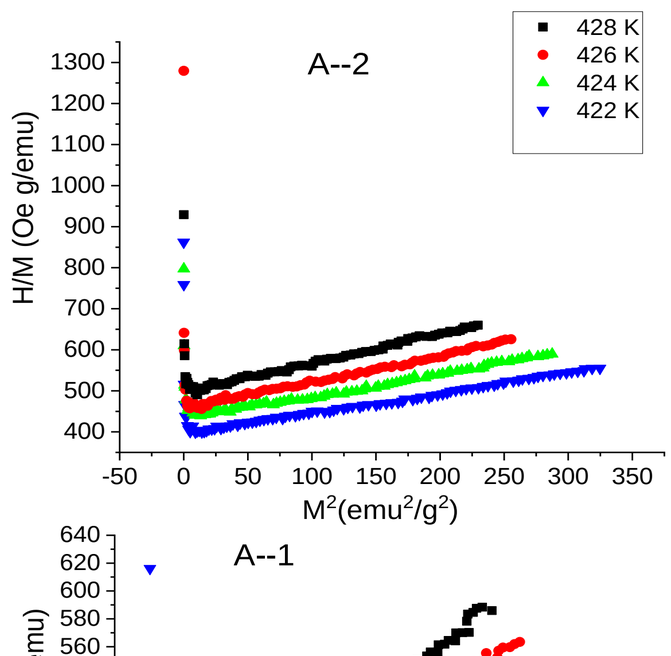
Figure 1. Temperature dependence of A–1, A–2 and A–3 samples magnetization, measured in magnetic field with induction B = 0.86 T. Insert: XRD patterns of A–1, A–2 and A–3 samples

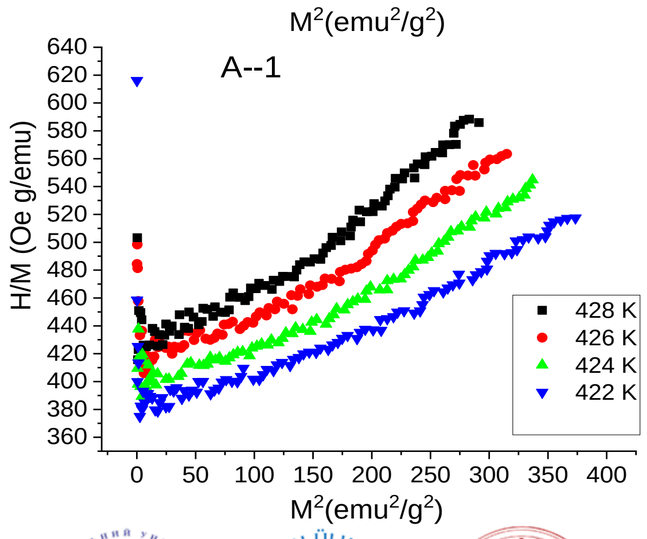


At room temperature (Fig. 1), the compounds have the tetragonal symmetry of the unit cell (spatial group I4/m), and at temperatures $T > T_C$ the compounds are characterized by the cubic symmetry of the unit cell Fm3m. The presence of the (101) and (103) reflexes (Fig.1, inset) indicates a formation of the superstructural ordering of iron and molybdenum (Fe/Mo) cations in the strontium ferromolybdate unit cell.

Figure 3. Arrott plots for A–1, A–2 and A–3 samples

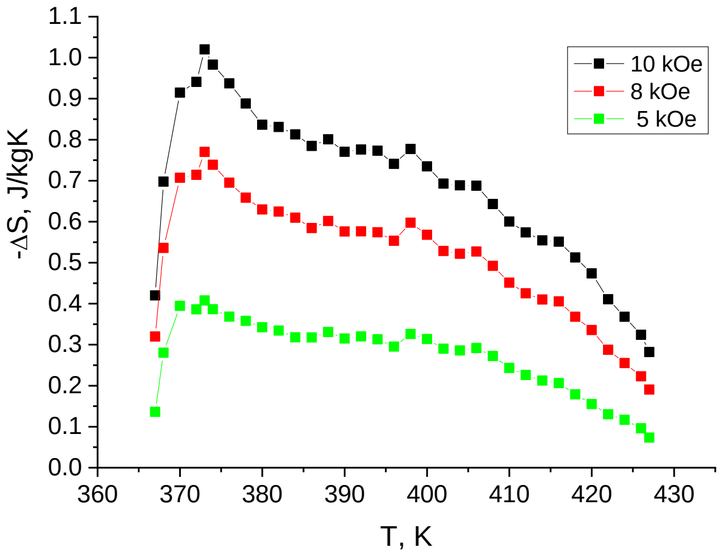






The sign of the slope for Arrott $H/M(M^2)$ plots is critical to determine the order of phase transition. According to Banerjee criterion, a negative slope corresponds to the first-order magnetic phase transition while a positive slope corresponds to the second-order magnetic phase transition. As it follows from Fig.3, all curves have a part with negative slope. Thus, phase transition at $T=T_C$ is the first-order one. Taking into account that this transition leads to almost zero magnetization on heating one can conclude that it is magnetostructural transition.

Figure 4. Magnetocaloric effect in A—3 sample



Isothermal change of entropy by magnetocaloric effect (Fig.4) was estimated based on Maxwell relation from isothermal magnetization curves shown in Fig.2. Numerical procedure was employed using approximate $|\Delta S_M| = \sum_i \frac{M_i - M_{i+1}}{T_{i+1} - T_i} \Delta H$ expression derived from Maxwell formulae

Conclusions:

- $Sr_2FeMoO_{6-\delta}$ samples with various δ prepared by the solid phase method have demonstrated different degree of iron and molybdenum cations superstructructural ordering: the samples with higher ordering possesses higher magnetization and Curie temperature;
- The samples underwent magnetostructural transitions of the first order with close characteristic (Curie) temperatures;
- The maximum of magnetocaloric effect observed nearby temperatures of the sharpest magnetization change was above 1 J/kgK