ON THE MECHANISM OF THE INDUCED ANISOTROPY
OF MAGNESIUM FERRITES
IN THE RANGE OF HIGHER TEMPERATURES*)

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A simple mechanism explaining not only the magnitude but also the type of induced anisotropy on the magnesium ferrite $\text{Mg}_{0.78}\text{Fe}_{2.22}\text{O}_{4.026}$ in the temperature range from 400 to 500$^\circ$K has been designed. The experimentally estimated values of the microscopic bond energy $l_\mu \approx 7 \times 10^{-16}$ erg of the configuration contributing to the F-type anisotropy and the activation energy $e_{\text{exp}} = 1.1$ eV are in good correspondence with the values $l_\mu \approx 1.6 \times 10^{-16}$ erg and $e_{a1} = 1.15$ eV which have been calculated theoretically.

1. INTRODUCTION

In paper [1] we investigated by the isothermal method the induced anisotropy of the monocrystal $\text{Mg}_{0.78}\text{Fe}_{2.22}\text{O}_{4.026}$ in the temperature range from 400 to 500$^\circ$K. It was found that the observed anisotropy is mostly of the F type. While the experimental values of the F term, as a function of temperature, are of the order of units $10^3$ erg cm$^{-3}$ (e.g. at the temperature $T = 430^\circ$K, $F \approx 6 \times 10^3$ erg cm$^{-3}$), the term $(1/2)G$ is small in the range under consideration; its value is at most 10% of the F value. Then we determined the activation energy $e_{\text{exp}} = 1.1$ eV characterizing the diffusion process by means of which the directional orientation of anisotropy carriers takes place. As follows from further measurements on $\text{Mg}_{x}\text{Fe}_{3-x}\text{O}_{4+y}$, samples, the values of the activation energy $e_{\text{exp}}$ (relative accuracy of measurement $\approx 5\%$) in the range $0.4 \leq x \leq 0.8$ are practically constant, i.e. independent on the content of magnesium in the sample. The magnitude of the activation energy $e_{\text{exp}} = 1.1$ eV and the fact that the arrangement occurs for $T > 0$ point to the possibility that the process is a matter of the diffusion of cations and vacancies. The aim of this communication is to design a simple model which could explain the observed experimental data [1].

2. THE TYPE AND MAGNITUDE OF INDUCED ANISOTROPY

For further consideration it is first necessary to know the distribution of cations and valences in the investigated sample $\text{Mg}_{0.78}\text{Fe}_{2.22}\text{O}_{4.026}$. That is why the temperature dependence of specific saturation magnetization $\sigma$ has been measured in the range from room temperature to 4.2$^\circ$K; the value $\sigma_0 = 33.28$ G cm$^{-1}$ g$^{-1}$ has been determined for the temperature 0$^\circ$K by extrapolation. Assuming Néel's antiparallel spin arrangement in the sublattices A and B, and taking into account the value $\sigma_0$ with

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the requirement of electric neutrality, one obtains for our case the following distribution of cations and valences

\[(\text{Mg}_{0.03}\text{Fe}_{0.97})^2\text{+}[\text{Mg}_{0.75}\text{Fe}_{0.16}\text{Fe}_{0.082}]^3\text{+}]\text{O}_{4.026},\]

where ( ) and [ ] are the tetrahedral and octahedral sites respectively. Therefore, the corresponding concentrations of cations in the B sites are

\[C = C_{\text{Mg}^2\text{+}} = 0.375; \quad C_{\text{Fe}^2\text{+}} = 0.084; \quad C_{\text{Fe}^3\text{+}} = 0.541.\]

The Mg\(^{2+}\) ions are diamagnetic and, consequently, they themselves cannot contribute to the observed anisotropy. However, having entered the octahedral sites in the spinel lattice, they influence the symmetry of the environment of the neighboring iron ions and hence also their anisotropy contribution. Simultaneously, there is some probability of the formation of configurations (of anisotropy carriers) with the axis of local symmetry clearly expressed. If the axes of local symmetry are orientated along the directions \langle 100 \rangle and \langle 111 \rangle the quantities \(F\) and \((1/2)G\) respectively, measured isothermally at the temperature \(T\), are given by the formula [2-4]

\[F = \frac{1}{3}N_F(kT)^{-1}l_F^2(T),\]

or

\[\frac{1}{2}G = \frac{2}{9}N_G(kT)^{-1}l_G^2(T),\]

where \(N_F, N_G\) is the number of anisotropy carriers per 1 cm\(^3\) orientated in the directions \langle 100 \rangle, \langle 111 \rangle respectively and \(l_F(T), l_G(T)\) are the corresponding energies of microscopic bond at the temperature \(T\); \(k\) is the Boltzmann constant.