Induced by magnetic field spin reorientation in YMn$_2$O$_5$

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Abstract

In ferroelectric YMn$_2$O$_5$ weak ferromagnetism was found along a-axis of rhombic crystal. It was shown that the nature of ferromagnetic sublattices cant is determined by magnetoelectric ordering. Reorientation of magnetic moment was observed under strong magnetic field applied along b-axis of crystal, that was accompanied by sharp increase of magnetostriction and jumps of electric polarization. In EuMn$_2$O$_5$, as in YMn$_2$O$_5$, spontaneous and magnetic field induced phase transitions from incommensurate to commensurate phase were observed, accompanied by cardinal changing of magnetoelectrical properties.

Key words: Magnetostriction; spin reorientation

Rare-earth oxide YMn$_2$O$_5$ is describing by orthorhombic space group $P_{bam}$, according to neutronography [1] below $T_N$ 40 K forms antiferromagnetic helicoidal structure of $Mn^{3+}$ and $Mn^{4+}$ spins and near $T_C = 20 K$ ferroelectrical phase transitions with spontaneous polarization appears [2] [3]. Rotation moment measurements carried out in static magnetic fields up to 12 kOe has shown the existence of weak ferromagnetism along a-axis below $T_N = 42 K$. This moment reaches the value of 0.8 emu/g at 4.2 K (Figure 1) that much larger than in [2]. It was shown that the nature of weak ferromagnetism linked with the existence electrical polarization along b-axis.

Strong magneto-electrical link existence in this compounds leads to appears of electrical polarization under magnetic field. Magneto-electric effect in these compounds was investigated earlier mainly in weak magnetic fields [2]. We carried out magneto-electrical measurements in strong pulse magnetic fields.

Electrical polarization at H along b-axis in the temperature range 20<T<40 K has a small value and quadratic dependence from field up to 250 kOe. How-

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![Fig. 1. Spontaneous magnetization of YMn$_2$O$_5$ singlecrystal.](image)

ever at T$_f$ 20 K polarization’s dependence from temperature and magnetic field changes qualitatively. At this temperature range and fields $H < H_p$ electrical polarization was very small, than at $H > H_p$ it had sharp jump (Figure 2).Critical fields decreased from 200 kOe at 10 K to 150 kOe at 20 K. Such character of electrical polarization dependence is linked with spontaneous electrical polarization $P_b$ appearance at $T_C = 20 K$. Below own ferroelectric transition temperature polarization jumps $P_b(H)$ in strong magnetic field can be interpreted as effect linked with chang-
ing the sign of electrical polarization at magnetic field induced spin reorientation of magnetic moment, because b-axis is the antiferromagnetism axis. Spin reorientation process must followed by the appearance of magnetoelastic deformities. At longitudinal magnetostriction measurements along b-axis sharp anomalies were observed at $T < 20 K$ and $H = H_p$. These anomalies have a correlation with character of electrical polarization from field.

At magnetic field orientation along a-axis of crystal near $T = 25 K$ character of electrical polarization dependence along c and b-axis sharply changed from temperature and field. Electrical polarization at $T > 25 K$ and $T < 25 K$ has a quadratic dependence from field. But at $T = 25 K$ and $H = 200 kOe$ $P_b(H_a)$ have sharp jumps of polarization with large hysteresis (Figure 3).

Possible reason of electrical polarization anomalies at 25 K and at $H > 250 kOe$ is the shift up the ferroelectric transition temperature. This own transition was observed at 20 K without field. Magneto electrical susceptibility of $YMn_2O_5$ along b-axis changes its sign at 20 K in weak magnetic field like it was for $EuMn_2O_5$ at $T = 29 K$, where according to neutronography transition [4] from commensurate to incommensurate phase occurs. It is not excepted that in $YMn_2O_5$ at 25 K external magnetic field may induce phase transition from incommensurate to commensurate, which can be followed by electrical polarization anomalies.

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References