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PROGRAM AND ABSTRACTS

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Tu-D-1.11-37

The electric structure transition for multiferroic $Cd_{1-x}Fe_xCr_2S_4$ ($0.0 \leq x \leq 0.9$)

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The electric structure transition by substituting Cd with Fe on tetrahedral site for multiferroic $Cd_{1-x}Fe_xCr_2S_4$ ($0.0 \leq x \leq 0.9$) was studied by SQUID, resistance measurement and Mössbauer spectroscopy. The crystal structures which were determined as cubic spinel (*Fd3m*) and a lattice parameter a_0 from 10.249 (x=0.0) to 10.019 Å(x=0.9) was decreased by substituting Fe. We found that Fe ion states were ferrous ions from isomer shift values. The electric structures changed from insulator to semiconductor with increasing Fe ions and the band gap energies are ranged from 0.004 to 0.12 eV which were calculated by the Arrhenius model. The resistances dependency on the temperature show cusp point at 145 and 165 K at x=0.7 and 0.9, respectively. It is in accordance with the magnetic Curie temperatures (T_C). Moreover, the change of magnetic behavior from ferromagnetic to ferrimagnetic at x=0.7 can be explained by the ion configuration and spin interaction. It was concluded that magnetic and electric structures were strongly correlated in these system.

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Magnetoelectric hexaferrite Zn_2-Y: thermal treatment and properties.*

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Hexaferrite type Y is a member of broad family of magnetic oxides attractive for various applications. Composition of $Ba_{0.5}Sr_{1.5}Zn_2Fe_{12}O_{22}$ has rich magnetic phase diagram including non-collinear magnetic order in which the magnetoelectricity was recently discovered [T. Kimura *et al.*, Phys. Rev. Lett. 94 137201 (2005)]. We have investigated polycrystalline samples prepared by liquid-mix technique and single crystal samples grown from flux. We have employed several experimental techniques (e.g. X-ray, nuclear magnetic resonance, impedance spectroscopy) to characterize samples exposed to different preparation conditions and following thermal treatment. The aim was to specify the features supposedly responsible or important for magnetoelectric behaviour, namely the distribution of Zn^{2+} and Fe^{3+} ions on tetrahedral sublattices, electrical conductivity and the amount of oxygen vacancies and ferrous ions.

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Magnetoelectric Properties of $(Ca_{1-x}Sr_x)_2CoSi_2O_7$ Crystals

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Since the discovery of novel ferroelectricity due to spiral spin structures in $TbMnO_3$, materials with spin frustration or nontrivial spin structures have attracted renewed interest as a promising candidate for new magnetoelectrics. Yi *et al.* have recently reported that $Ba_2CoGe_2O_7$ is a new class of multiferroic materials. In this context, we have focused on $Ca_2CoSi_2O_7$ and $Sr_2CoSi_2O_7$, which have the same crystal structure as $Ba_2CoGe_2O_7$, as the new multiferroic materials. Both compounds show the large magnetocapacitance, however, their magnetoelectric properties are quite different from each other. $Ca_2CoSi_2O_7$ shows the magnetic-field-induced electric polarization, while $Sr_2CoSi_2O_7$ does not. For further understanding of the magnetoelectric properties of this system, we have investigated the magnetoelectric properties of $(Ca_{1-x}Sr_x)_2CoSi_2O_7$ ($0 \leq x \leq 1$) crystals.

Tu-D-1.11-40

Magnetic properties of single crystals $Nd_{1-x}Dy_xFe_3(BO_3)_4$

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$Nd_{0.9}Dy_{0.1}Fe_3(BO_3)_4$ and $Nd_{0.75}Dy_{0.25}Fe_3(BO_3)_4$ crystals were grown and magnetic properties were investigated. Rare-earth ferroborates is interested due to very strong electric polarization which induced by magnetic field. The experiments on single crystals with double rare-earth subsystem, for example, of the solid solution $NdFe_3(BO_3)_4$ and $DyFe_3(BO_3)_4$ for interpretation of magnitoelectric polarization microscopic mechanism are interested. It was noted that magnetic behavior essentially depends on x. So samples with x = 0.1 and x = 0.25 has spontaneous and induced magnetic field $\mathbf{H} \| C_3$ spin-reorientation transitions in contrast to easy-plane $NdFe_3(BO_3)_4$ and easy-axis $DyFe_3(BO_3)_4$. These transitions have taken place because of competition anisotropy easy-plane and easy-axis subsystem.

Tu-D-1.11-41

Magnetic Structure of the Field-Induced Polarization Phases of Rare Earth Ferroborates*

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We report magnetic x-ray scattering studies of the field-induced multiferroics $GdFe_3(BO_3)_4$ and $NdFe_3(BO_3)_4$ in a magnetic field. The combination of resonant— at the rare earth L edges— and nonresonant scattering allows the behaviors of the rare earth and iron magnetic subsystems to be unraveled. Both materials are found to exhibit commensurate and incommensurate magnetic phases below T_N in zero field. In the field-induced polarization phase of $GdFe_3(BO_3)_4$, the magnetic structure is believed to be commensurate as evidenced by a decrease in the magnetic peak width observed at T = 25 K for magnetic field applied along the *a* axis. In $NdFe_3(BO_3)_4$, in which the zero field incommensurability is much larger than that in $GdFe_3(BO_3)_4$, the incommensurability at T = 1.8 K decreases for H > 0.6 T and the magnetic structure is commensurate for H $\geq$ 0.9 T. Our results and a comparison to polarization data indicate a correlation between the field-induced destruction of incommensurate magnetic phases and multiferroic behavior in the rare earth ferroborates.

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Tu-D-1.11-42

Direct evidence of frustration effects in Multiferroic material using by high-field Mössbauer spectroscopy

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We have investigated that weak frustration effects for $CoCr_{1.98}{}^{57}Fe_{0.02}O_4$ are used by high-field Mössbauer spectroscopy. Mössbauer spectra taken at 30 K with 4.8 T applied field show that the spin structure of $CoCr_{1.98}{}^{57}Fe_{0.02}O_4$ has the saturated magnetic moment caused by collinear Néel model. Therefore, the second and fifth lines of the Mössbauer patterns vanished with 4.8 T applied filed. In case of Mössbauer spectra taken at 4.2 K with 4.8 T applied field, the second and fifth lines of the Mössbauer patterns remained weakly. We observed that high-field Mössbauer spectra comprehend with spin behaviour of Cr ions changed incommensurate(Non-collinear) at 4.2 K to commensurate (collinear) states at 30 K. We provide direct evidence using high-field Mössbauer that $CoCr_{1.98}{}^{57}Fe_{0.02}O_4$ have frustration effects.