

Room-temperature multiferroic behavior in layer-structured Aurivillius phase ceramics

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ABSTRACT

Multiferroic Aurivillius phase ceramics (M₂A₂B₅F₃O₁₅) exhibit room-temperature multiferroic behavior. The structure of these ceramics is based on the Aurivillius layer structure, which consists of alternating layers of perovskite and Bi₂O₂ layers. The multiferroic behavior is attributed to the presence of the Aurivillius layer structure, which allows for the coexistence of ferroelectric and magnetic orders. The room-temperature multiferroic behavior is observed in the Aurivillius phase ceramics, which is a significant finding for the development of multiferroic materials. The structure of the Aurivillius phase ceramics is based on the Aurivillius layer structure, which consists of alternating layers of perovskite and Bi₂O₂ layers. The multiferroic behavior is attributed to the presence of the Aurivillius layer structure, which allows for the coexistence of ferroelectric and magnetic orders. The room-temperature multiferroic behavior is observed in the Aurivillius phase ceramics, which is a significant finding for the development of multiferroic materials.

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B_{2cb} $a = 5.4530(2)$ Å, $b = 5.4427(1)$ Å, $c = 50.670(2)$ Å
 A_{21am} $a = 5.4651(6)$ Å, $b = 5.3943(6)$ Å, $c = 41.487(2)$ Å

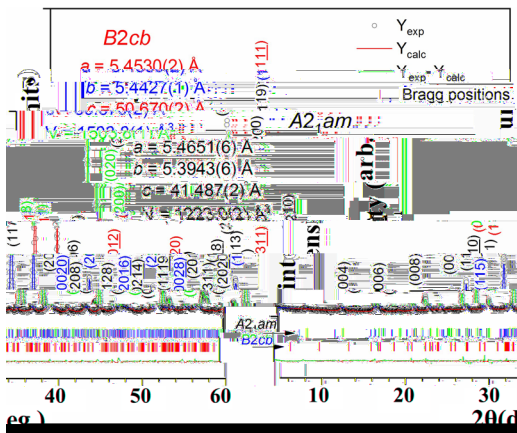


FIG. 1. XRD patterns of B2cb and A21am phases.

BLFC $B_6F_{0.5}C_{0.5}O_{15}$ $a = 5.4530(2)$ Å, $b = 5.4427(1)$ Å, $c = 50.670(2)$ Å
 BLFC $B_6F_{0.5}C_{0.5}O_{15}$ $a = 5.4651(6)$ Å, $b = 5.3943(6)$ Å, $c = 41.487(2)$ Å

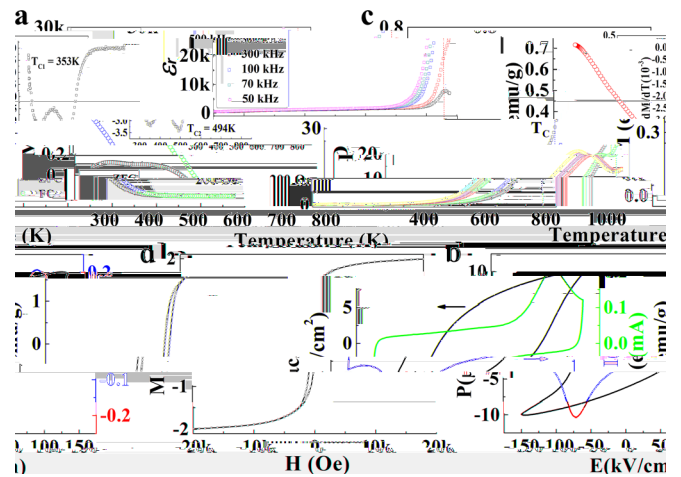


FIG. 2. Temperature-dependent magnetization and magnetoelectric effect of BLFC. (a) Magnetization (M) vs magnetic field (H) at $T_c = 353$ K and $T_c = 494$ K. (b) Magnetization (M) vs magnetic field (H) at $T_c = 494$ K. (c) Magnetization (M) vs electric field (E) at $T_c = 494$ K. (d) Magnetization (M) vs magnetic field (H) at $T_c = 494$ K. (e) Magnetization (M) vs electric field (E) at $T_c = 494$ K.

~ 494 K
 $B_6FC_3O_{18}$ (526 K).²³
 BLFC
 $F^{3+} O F^{3+}, C_a^{3+} O C_a^{3+}, F^{3+} O C^{3+}$ (\dots).²⁴
 ED
 FC ~ 353 K
 $C_2F_2O_4$ (460 K)
 (M) $C_2F_2O_4$.^{16,25}
 16.235 / \dots
 $C_{2-} F_a O_4$ 0.22 0.32 / \dots
 $M = 1.85$ / $F_a \cdot 2(\dots)$ I_a $M H$
 $2(F_a \cdot 3)$ 425 K 1.58 / \dots 0.27 / \dots
 ED
 $BLFC$
 $F_a \cdot 3$
 (DF) $F^{3+} O C^{3+}$ *ab initio*
 (A) H_a
 $F = 2$ $C = 3$ F_a C_a
 $(GGA) + \dots$ I
 $BLFC$ F^{3+} C^{3+} (3.1 $2.1 \mu_B/a$)
 $0.1 \mu_B/a$
 $F O_6$ $C O_6$ F/C $F \cdot 3(\dots)$
 F_a O_a F^{3+} C^{3+}
 (\dots) (\dots)
 $E_{FM} - E_{AFM}$
 $= -144.1$
 H_a 43.5 (\dots , 504.6 K), (FM) FM
 FC/FC $F \cdot 2(\dots)$ $a b$
 010
 $BLFC$ $F_a \cdot 4$ I_a
 I_a

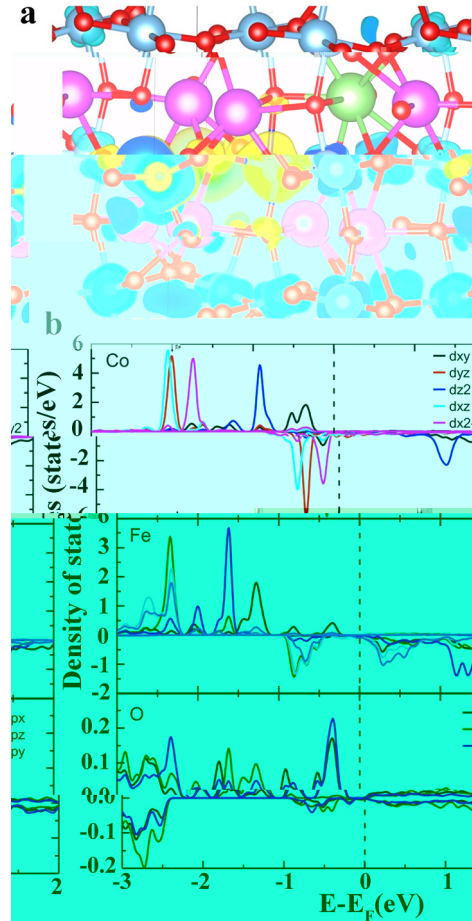


FIG. 3. (a) Crystal structure of BLFC. (b) Density of states (DOS) for Co, Fe, and O atoms. The DOS is plotted in units of states/eV versus energy $E - E_F$ (eV). The legend indicates the contributions of different orbitals: dx_{2-y^2} (black), dyz (red), dz^2 (blue), dxz (green), and dx^2-y^2 (purple).

N
 I $F_a \cdot 4$ $(0, 1, 20)$
 $(2 \leq H < 5)$
 $M H$ $F_a \cdot 2(\dots)$ $3_a F$
 $BLFC$ $F M$
 FM $BLFC$ $399 O$
 $5(\dots)$ F

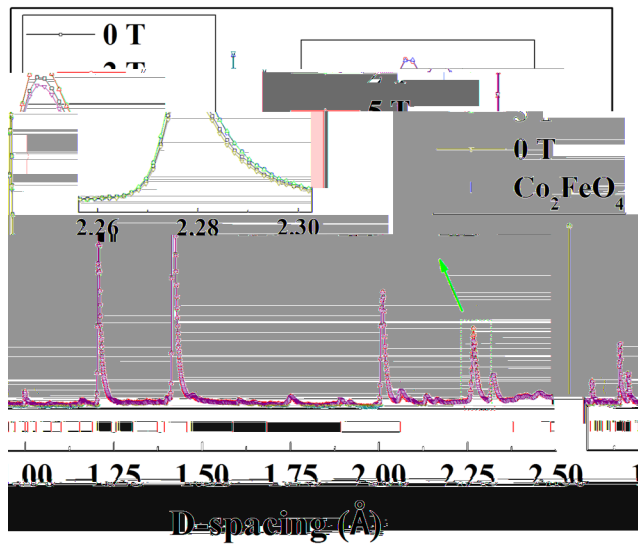


FIG. 4. XRD patterns of Co_2FeO_4 at 0 T, 2 T, and 5 T. The inset shows the schematic of the sample and measurement setup.

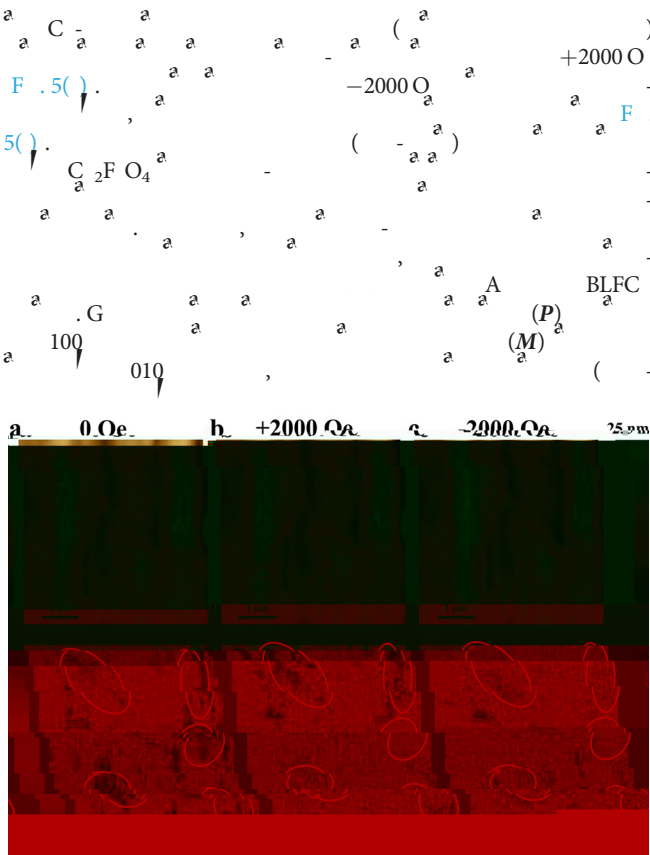


FIG. 5. MFM images of Co_2FeO_4 at 0 Oe, +2000 Oe, and -2000 Oe. The inset shows the schematic of the sample and measurement setup.

$T = P \times M$
 BLFC
 $\text{C}^{3+} \text{O}_2 \text{C}^{3+}$, $\text{F}^{3+} \text{O}_2 \text{C}^{3+}$, $\text{F}^{3+} \text{O} \text{F}^{3+}$
 $\text{C}_2\text{F}_2\text{O}_4$
 EM (ED)
 BLFC
 $\text{D} \cdot \text{M}$, $\text{D} \cdot \text{K}$, D
 I H I I N
 D , O , K
 A^a , E , D , F
 G^a , A , A^a , A^a , F (G^a , N^a , $2/$
 $0038/20$), C (G^a , N^a , $\text{K}2015-0602006$), $\text{N}^a \text{FC}$ (G^a
 N^a , 11474138 , 11834005). A^a
 E , M (EM)
 $\text{IND}54$, N^a , EM
 EM , E , AME , E

DATA AVAILABILITY

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