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ABSTRACT

Multiferroic behavior is observed in layer-structured Aurivillius phase ceramics $B_{5.25}L_{0.75}F_{1-x}C_xO_{18}$ ($x = 0, 0.25, 0.5, 0.75, 1$) at room temperature. The $B_{5.25}L_{0.75}F_{1-x}C_xO_{18}$ ceramics exhibit a transition from a paraelectric (PE) state to a ferroelectric (FE) state at room temperature. The transition temperature T_C increases with the C/F ratio. The $B_{5.25}L_{0.75}F_{1-x}C_xO_{18}$ ceramics exhibit a transition from a paraelectric (PE) state to a ferroelectric (FE) state at room temperature. The transition temperature T_C increases with the C/F ratio. The $B_{5.25}L_{0.75}F_{1-x}C_xO_{18}$ ceramics exhibit a transition from a paraelectric (PE) state to a ferroelectric (FE) state at room temperature. The transition temperature T_C increases with the C/F ratio.

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$B_{5.25}L_{0.75}F_{1.0}C_{1.0}O_{18}$
 $(BLFC)$
 L
 F , A , C , D
 a b
 $BLFC$
 a b
 A
 $in situ$
 I H , D , O , K
 N F
 A $BLFC$
 $BLFC$
 F 1 (D) $BLFC$
 $B2cb$ A
 A_{21}
 A $B2cb$ $a = 5.4530(2) \text{ \AA}$, $b = 5.4427(1) \text{ \AA}$,
 $c = 50.670(2) \text{ \AA}$ A_{21am} $a = 5.4651(6) \text{ \AA}$,
 $b = 5.3943(6) \text{ \AA}$, $c = 41.487(2) \text{ \AA}$
 F $(//$

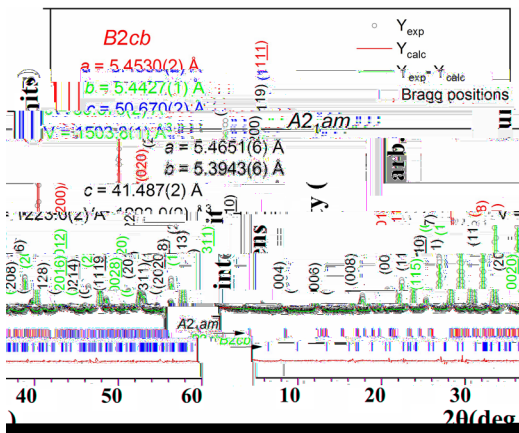


FIG. 1. XRD patterns of B2cb and A21am phases.

$BLFC$ F 1 EM $(a-b)$ M
 F 1 1.4 $\%$, $(F$ 2
 D ED $(F$ 2
 $1)$
 F , C , O , C $2F$ O_4
 A $B_{5F}O_{0.5}C_{0.5}O_{15}$ ¹⁶
 $BLFC$
 $(50, 70, 100,$
 $300, 500 \text{ H})$. $FE T$ $BLFC$ H , $B_{6}F_{3}O_{18}$
 1060 K $BLFC$ $2()$ $P-E$ $I-E$
 (973 K) ¹³ $BLFC$ $I-E$
 $BLFC$ $I-E$
 $BLFC$ $10 \mu C/$ 2 .
 F $2()$ (FC) (FC) 200 O $BLFC$ $BLFC$

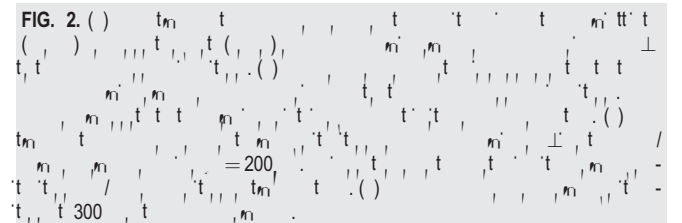
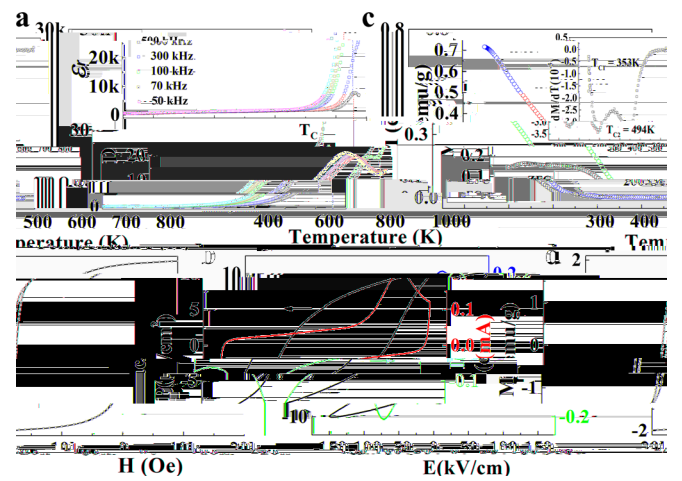


FIG. 2. Magnetization (M) versus magnetic field (H) for BLFC at different temperatures (tm).

~ 494 K
 M/μ_B ,
 $B_6F_2C_{18}O_{18}$ (526 K).²³
 BLFC
 $F^{3+} O F^{3+}, C^{3+} O C^{3+}, F^{3+} O C^{3+}$ ().²⁴
 ED
 ~ 353 K
 FC
 $C_2F_4O_4$ (460 K)
 $(M) C_2F_4O_4$ 16,25
 $16.235 /$,
 $C_2F_4O_4$ 0.22 0.32 / , 1.4 %
 $M = 1.85 /$, $F = 2(1.1)$ BLFC
 $M H$
 ~ 425 K 1.58 / ,
 $0.27 /$, ED
 $BLFC$
 A
 $F^{3+} O C^{3+}$ *ab initio*
 (DF)
 (A)
 $\mu_F = 2$, $\mu_C = 3$, F , C ,
 $(GGA)+$, I
 $BLFC$
 $F = 3(1)$, F^{3+} , C^{3+} (3.1 2.1 μ_B / ,) ,
 $(0.1 \mu_B /)$.
 $F O_6$, $C O_6$
 (F) , F/C ,
 F , O / , $F = 3(1)$.
 F^{3+} , C^{3+} ,
 (\dots) ,
 (\dots) ,
 $E_{FM} - E_{AFM}$
 $= -144.1$.
 H ,
 43.5 (, 504.6 K), (FM)
 ~ 1 FC/FC , $F = 2(1)$,
 $a b$
 010
 $BLFC$, I
 $F = 4$
 $BLFC$, I

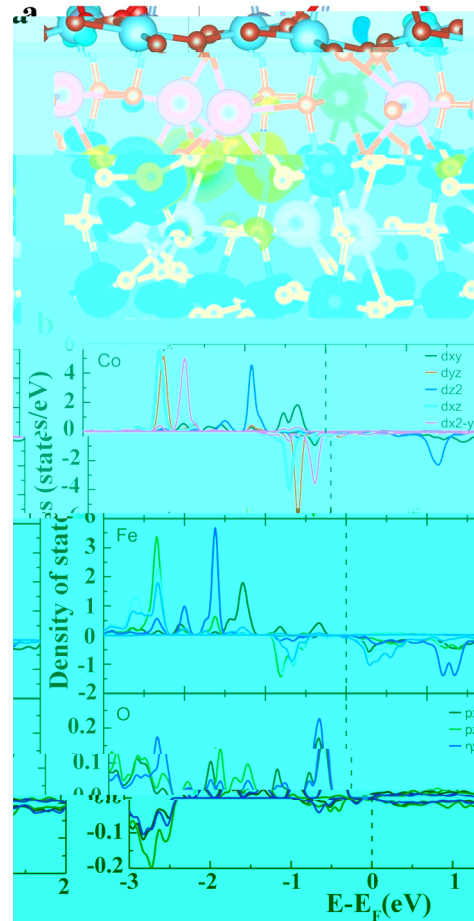


FIG. 3. (a) Crystal structure of BLFC. (b) Density of states (DOS) for Co, Fe, and O atoms. The DOS is calculated using the GGA+U method with $U = 0.005$ eV. The x-axis is $E - E_f$ (eV) and the y-axis is Density of states (states/eV).

~ 399 O
 $F = 4$
 $(0 1 20)$
 $2 F$
 $(2 < H < 5)$,
 $M H$, $F = 2(1)$, $3 F$,
 $F = 5$
 $BLFC$, $F M$
 FM , $BLFC$,
 $5(1) A$, $F = 4$

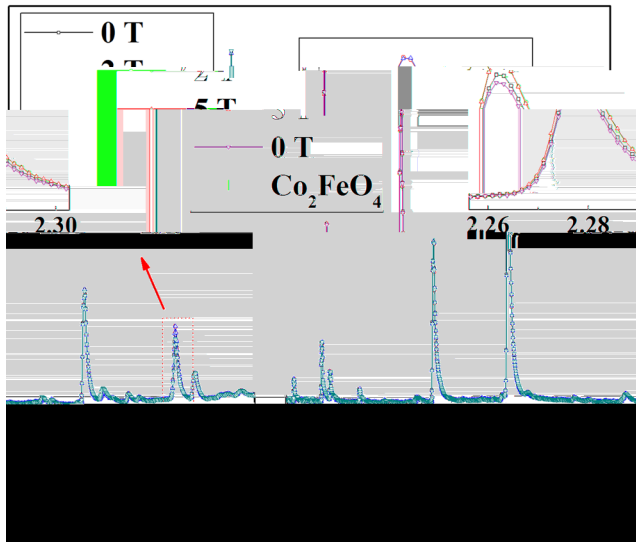


FIG. 4. XRD patterns of Co_2FeO_4 at 0 T and 5 T. The inset shows the magnified view of the peak at $2\theta \approx 2.26^\circ$.

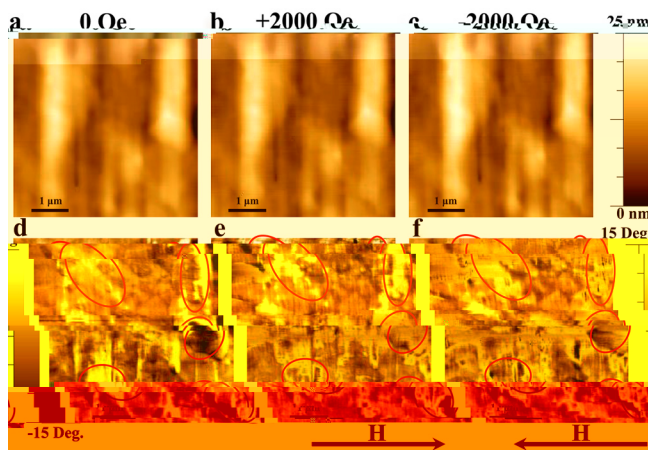
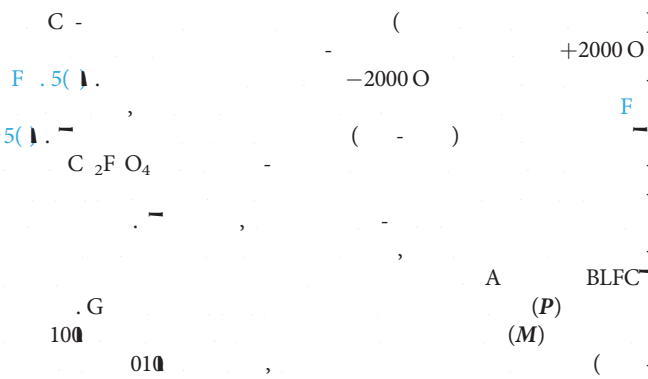


FIG. 5. MFM images of BLFC at 0 Oe, +2000 Oe, and -2000 Oe. The inset shows the magnified view of the magnetic domain structure.

$T = P \times M$
 BLFC
 I , A BLFC
 F
 $\text{C}^{3+} \text{O} \text{C}^{3+}$, $\text{F}^{3+} \text{O} \text{C}^{3+}$ $\text{F}^{3+} \text{O} \text{F}^{3+}$
 A , C / F
 EM (ED) BLFC
 D . M , D . K , D.
 D I H I I N , AL,
 D , O , K.
 A E D F
 G A A A (G N . 2/
 0038/20), C (G N . K2015-0602006), N FC (G
 N . 11474138 11834005). A
 E M (EM)
 IND54 N EM
 EM E AME E

DATA AVAILABILITY

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