





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

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AFFILIATIONS

¹G...
²I...
³E...
⁴N...
⁵N...
⁶E...
⁷L...

^{a)}Email: ...
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ABSTRACT

M...
 H...
 A...
 B_{5.25}L_{0.75}F₃C₃O₁₈
 P...
 A...
in situ
 F³⁺ O F³⁺, C³⁺ O C³⁺, F³⁺ O C³⁺
 A...
 C / F

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M... (FM) (FE) A... B₅F₃O₁₅ (=4) B₆F₂O₁₈
 (=5), B₄F₃O₁₂
 B F O₃, FE FM ^{12,13}B
 C F B- B₅F_{0.5}C_{0.5}O₁₅
 (=4) B₆F₃C₃O₁₈ (=5)
⁵ (B₂O₂)²⁺(A₁B O₃ +1)²⁻ (A... ^{14,15}H...
 12-... B...
)⁶... ¹⁶...
 B-... A
 B F O₃... ^{7 11}...

I (BLFC) P L A B_{5.25}L_{0.75}F C₃O₁₈ (P). BLFC = 4 = 5 A . N

F, A C, D^{14,17} BLFC F 1 EM (a-b) M

BLFC a b A a b P

A in situ I H I I N F AL, D O U K

(P). P A BLFC

BLFC P

F 1 (D) BLFC

B2cb A

A A₂₁

A B2cb a = 5.4530(2) Å, b = 5.4427(1) Å, c = 50.670(2) Å A₂₁am a = 5.4651(6) Å, b = 5.3943(6) Å, c = 41.487(2) Å F P (//

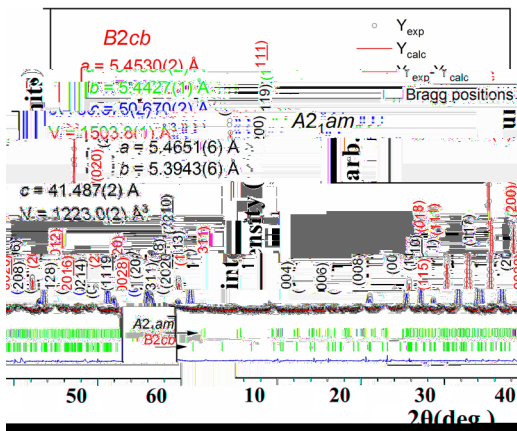


FIG. 1. XRD pattern of B2cb.

BLFC = 4 = 5 A . N

BLFC F 1 EM (a-b) M

F 1 1.4 %, (F 2

D. ED

1) F, C, O, C₂F O₄

A B₅F_{0.5}C_{0.5}O₁₅¹⁶

BLFC (50, 70 100, 300, 500 H). FE T BLFC H, B₆ F₃ O₁₈

1060 K BLFC 2() P-E I-E

BLFC P I-E

BLFC 10 μC/ 2. (FC) BLFC

F 2() 200 O BLFC BLFC

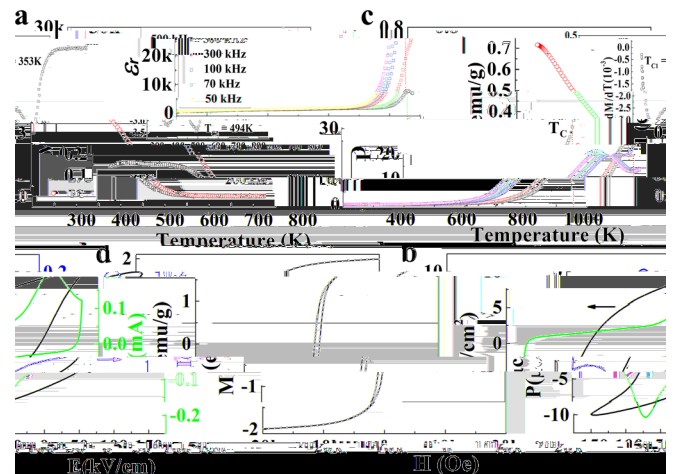


FIG. 2. (a) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (b) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (c) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (d) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (e) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (f) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (g) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (h) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (i) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (j) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (k) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (l) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (m) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (n) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (o) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (p) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (q) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (r) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (s) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (t) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (u) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (v) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (w) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (x) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (y) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz. (z) Plot of dielectric loss ε'' (m.u/g) vs Temperature (K) for frequencies 300 kHz, 100 kHz, 70 kHz, and 50 kHz.

~ 494 K
 $M/$),
 $B_6F C_3O_{18}$ (526 K).²³
 BLFC
 $F^{3+} O F^{3+}, C^{3+} O C^{3+}, F^{3+} O C^{3+}$ (.
 ED).²⁴
 A FC $2 \sim 353$ K
 $C_2F O_4$ 2 $16,25$
 $C_2F O_4$ (460 K)
 $(M) C_2F O_4$
 $16 \ 23.5 \ /$.²⁵ , $1.4 \ .\%$
 $C_{2-} F O_4$ $0.22 \ 0.32 \ /$,
 $M = 1.85 \ /$, $F . 2() . I$ BLFC
 $M H$
 $2 (F . 3)$ 1
 425 K $1.58 \ /$.
 $0.27 \ /$,
 ED
 $BLFC$
 A
 $F 3$
 (DF) $F^{3+} O C^{3+}$ *ab initio*
 $(A P)$ H
 $U_F = 2$ $U_C = 3$ $F C$,
 $(GGA)U$. I
 $BLFC$
 $F . 3()$, $F^{3+} C^{3+}$ (3.1 $2.1 \mu_B/$,) ,
 O
 $(0.1 \mu_B/)$.
 $F O_6 C O_6$
 $()$ F/C -
 F O - $/$. $F . 3()$.
 $F^{3+} C^{3+}$ -
 $(. ,)$ $(. ,)$.
 $E_{FM} - E_{AFM}$
 $= -144.1$.
 H , (FM)
 43.5 (. , 504.6 K),
 1 FC/FC $. F . 2()$.
 $a b$
 010 .
 $BLFC$ $F 4$. I
 $P F M$
 $5() . A$ $BLFC$ $P F M$
 $399 O$.
 $F .$
 $F -$

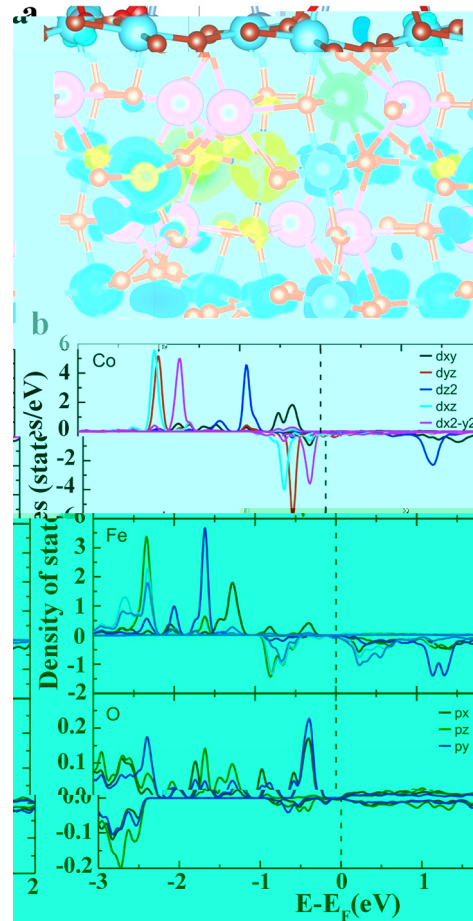


FIG. 3. (a) Crystal structure of BLFC. (b) Density of states (DOS) for BLFC. The DOS is calculated using the GGA+U method with $U = 0.005$ eV. The DOS is plotted for Co, Fe, and O atoms. The Fermi level E_F is indicated by a vertical dashed line at 0 eV.

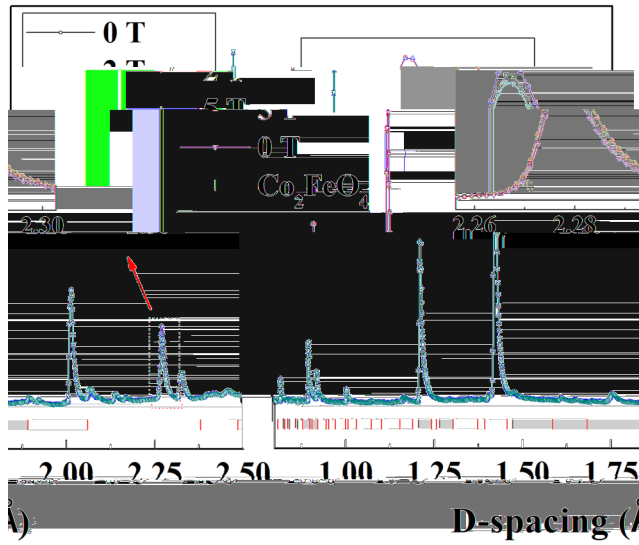


FIG. 4. XRD patterns of BLFC film at 0 T, +2000 Oe, and -2000 Oe. The inset shows the schematic of the BLFC film structure.

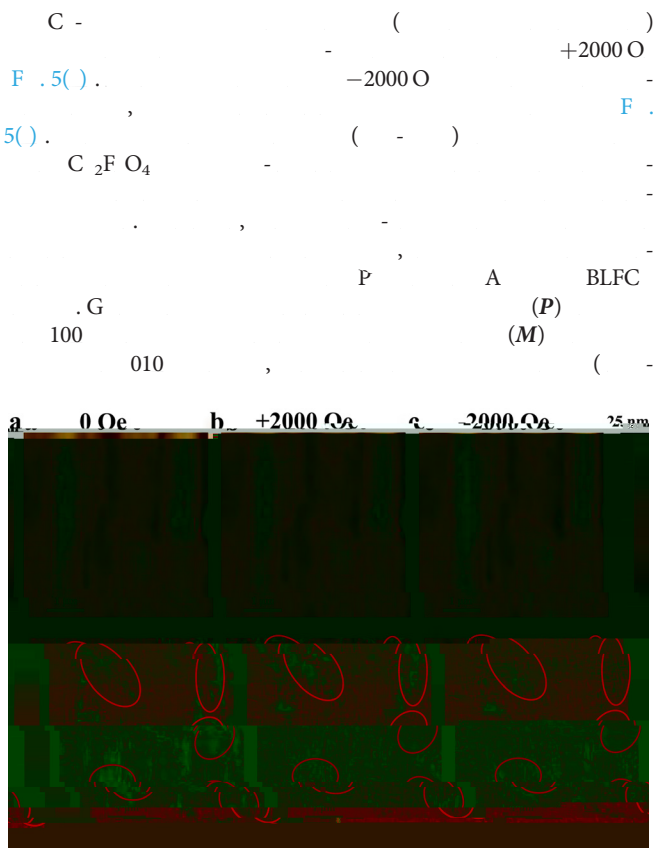


FIG. 5. SEM images of BLFC film surface at 0 Oe, +2000 Oe, and -2000 Oe. The inset shows the schematic of the BLFC film structure.

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

DATA AVAILABILITY

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 $B_4 O_{12}$, A . K **1**(58), 499 512 (1949).
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