





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

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ABSTRACT

Multiferroic Aurivillius phase ceramics (APCs) have attracted much attention due to their unique layered structure and rich physical properties. However, the room-temperature multiferroic behavior of APCs is still a challenge. In this work, we report the room-temperature multiferroic behavior of the layer-structured Aurivillius phase ceramic $B_{5.25}L_{0.75}F_{0.5}C_{0.5}O_{18}$. The structure of the ceramic is investigated by X-ray diffraction and electron microscopy. The room-temperature magnetic and ferroelectric properties are studied by magnetization and polarization measurements. The results show that the ceramic exhibits a room-temperature magnetic transition and a ferroelectric transition. The room-temperature multiferroic behavior is attributed to the presence of the F^{3+} and C^{3+} ions in the structure. The room-temperature multiferroic behavior is investigated by *in situ* X-ray diffraction and electron microscopy. The results show that the room-temperature multiferroic behavior is attributed to the presence of the F^{3+} and C^{3+} ions in the structure.

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Multiferroic Aurivillius phase ceramics (APCs) have attracted much attention due to their unique layered structure and rich physical properties. However, the room-temperature multiferroic behavior of APCs is still a challenge. In this work, we report the room-temperature multiferroic behavior of the layer-structured Aurivillius phase ceramic $B_{5.25}L_{0.75}F_{0.5}C_{0.5}O_{18}$. The structure of the ceramic is investigated by X-ray diffraction and electron microscopy. The room-temperature magnetic and ferroelectric properties are studied by magnetization and polarization measurements. The results show that the ceramic exhibits a room-temperature magnetic transition and a ferroelectric transition. The room-temperature multiferroic behavior is attributed to the presence of the F^{3+} and C^{3+} ions in the structure. The room-temperature multiferroic behavior is investigated by *in situ* X-ray diffraction and electron microscopy. The results show that the room-temperature multiferroic behavior is attributed to the presence of the F^{3+} and C^{3+} ions in the structure.

$B_{5.25}F_{0.75}C_{18}O_{18}$
 $(BLFC)_{a,b}$
 $a = 5.4530(2) \text{ \AA}$, $b = 5.4427(1) \text{ \AA}$,
 $c = 50.670(2) \text{ \AA}$, $c = 41.487(2) \text{ \AA}$
 $b = 5.3943(6) \text{ \AA}$, $c = 41.487(2) \text{ \AA}$

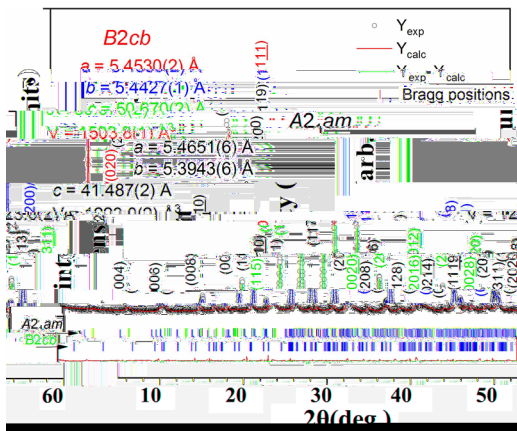


FIG. 1. XRD patterns of BLFC powder.

$B_{5.25}F_{0.75}C_{18}O_{18}$
 $(BLFC)_{a,b}$
 $a = 5.4530(2) \text{ \AA}$, $b = 5.4427(1) \text{ \AA}$,
 $c = 50.670(2) \text{ \AA}$, $c = 41.487(2) \text{ \AA}$
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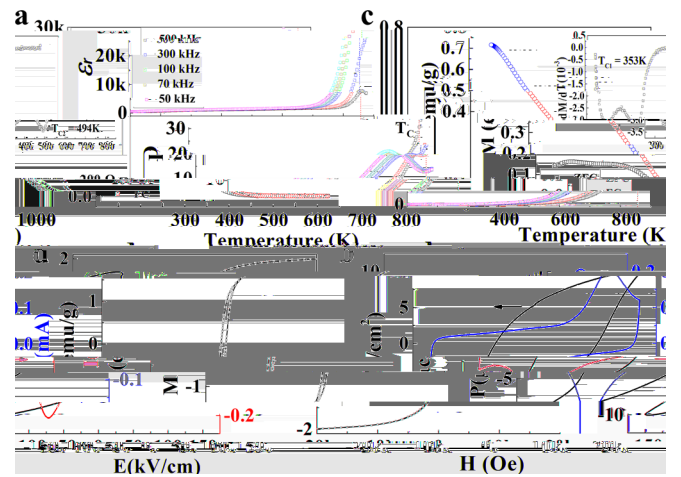


FIG. 2. (a) Temperature dependence of dielectric permittivity (ϵ') and loss tangent ($\tan \delta$) for BLFC. (b) Temperature dependence of the piezoelectric coefficient (d_{33}) and the pyroelectric coefficient (P). (c) Temperature dependence of the ferroelectric polarization (P) and the ferroelectric transition temperature (T_c) for BLFC.

~ 494 K
 M/μ_B ,
 $B_6F_2C_{18}O_{18}$ (526 K).²³
 BLFC
 $F^{3+} O F^{3+}, C^{3+} O C^{3+}, F^{3+} O C^{3+}$ (.
 ED
 ~ 353 K
 $C_2F_4O_4$ (460 K)
 $(M) C_2F_4O_4$ 16,25
 $16 \ 23.5 \ /$.²⁵ , 1.4 . %
 $C_2F_4O_4$ 0.22 0.32 / , BLFC
 $M = 1.85 \ /$, $F . 2(\ 1 . I$, M H
 ~ 425 K 1.58 / .
 $0.27 \ /$, ED
 BLFC
 $F^{3+} O C^{3+}$
 (DF)
 (A) H *ab initio*
 $\mu_F = 2 \ \mu_C = 3$ F C ,
 (GGA)+ μ . I
 BLFC
 $F . 3(\ 1 , F^{3+} C^{3+} (3.1 \ 2.1 \ \mu_B/$,) ,
 $(\ 0.1 \ \mu_B/)$.
 $F O_6 C O_6$
 $(\)$ F / C - / $F . 3(\ 1 .$
 F $F^{3+} C^{3+}$,
 $(\ , \)$,
 $= -144.1$.
 H , (FM)
 $43.5 \ (\ , 504.6 K)$ FM
 ~ 1 FC/FC $F . 2(\ 1 .$
 $a \ b$
 010
 BLFC $F . 4$. I
 $399 O$.
 $F .$
 $F -$

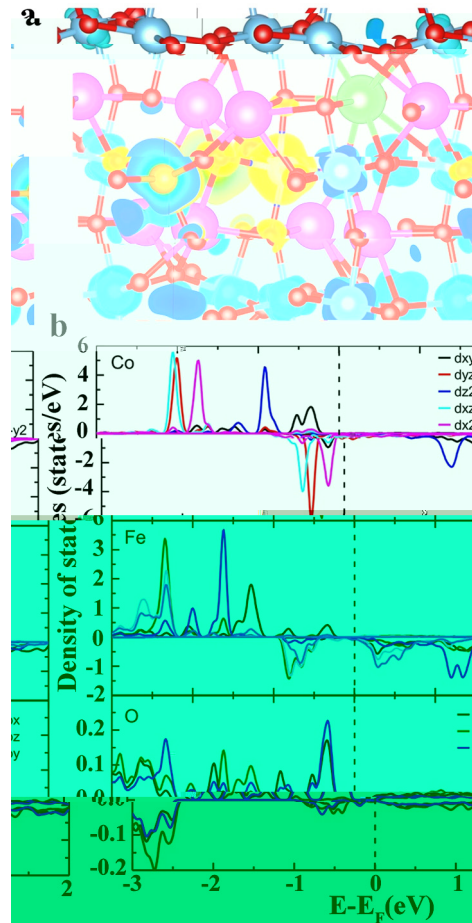


FIG. 3. (a) Crystal structure of BLFC (BiFeO₃) showing the arrangement of Bi (pink), Fe (blue), and O (red) atoms. (b) Density of states (DOS) plots for Co, Fe, and O atoms, showing the contribution of different d-orbitals (d_{xy}, d_{yz}, d_{z²}, d_{xz}, d_{x²-y²}) to the total DOS. The x-axis is E - E_f (eV) and the y-axis is Density of states (states/eV).

. N
 . I
 $F . 4$
 $(0 \ 1 \ 20)$
 $2 \ . \ F$
 $(2 \ < H < 5 \)$,
 $2 \ ,$ M H $F . 2(\)$ 3. F ,
 $F . 5$
 BLFC
 F M
 $399 O$.
 $F .$
 $F -$

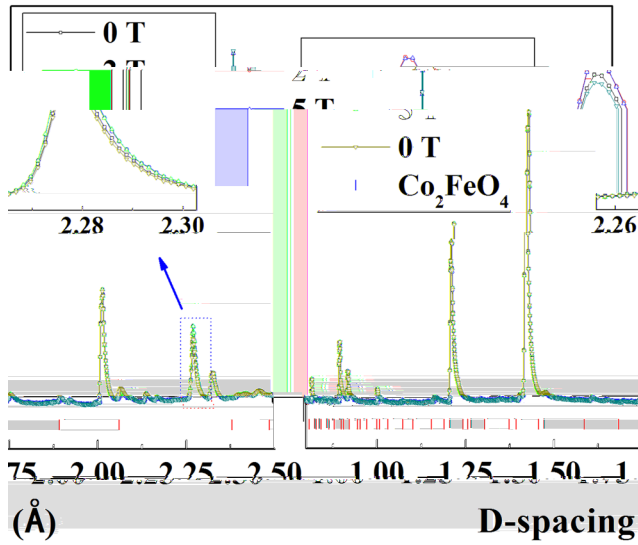


FIG. 4. XRD patterns of Co_2FeO_4 at 0 T and 5 T. The inset shows the zoomed-in view of the 2.28–2.30 Å region.

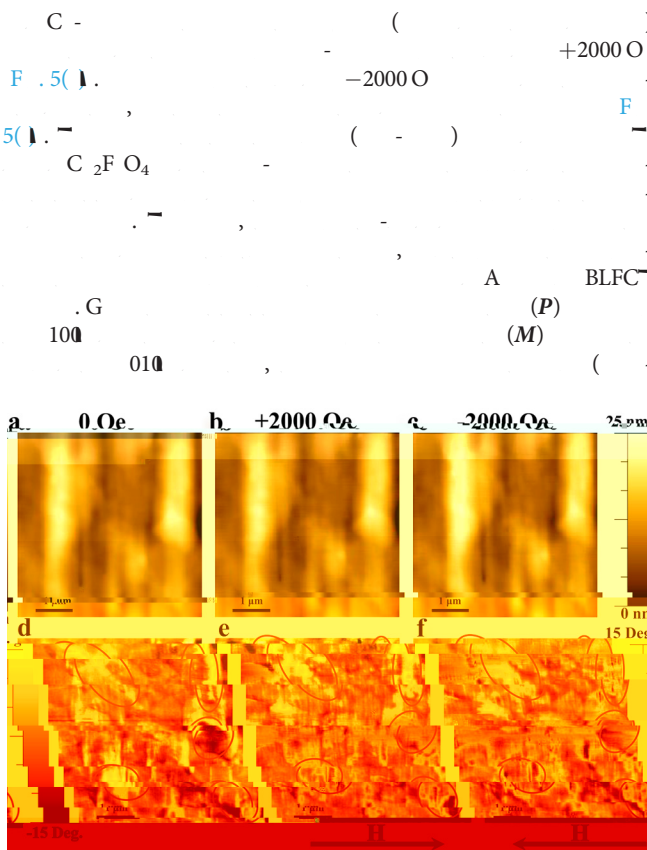


FIG. 5. MFM images of Co_2FeO_4 at different magnetic fields. (a) 0 Oe, (b) +2000 Oe, (c) -2000 Oe. The inset shows the zoomed-in view of the 2.28–2.30 Å region.

$T = P \times M$
 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 (G N . 2/
 0038/20), C (G N . K2015-0602006), N FC (G
 N . 11474138 11834005). A
 E M (EM)
 IND54 N EM E

DATA AVAILABILITY

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