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

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AFFILIATIONS

[1]G , C , G , 430074, C
[2] M r A 47, K 04001,
[3] E K M r M r L , L E1 4N, K
[4]N K L r r D l F , C A E K M , 621900, C
[5]N L r r, H 11 0L , K
[6]E L, F rr G 99 , K
[7] , L , L 730000, C

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ABSTRACT

M . H , - . A , D . H , A $B_{5.25}L_{0.75}FC_3O_{18}$. A , *in situ* F $^{3+}$ O F $^{3+}$, C $^{3+}$ O C $^{3+}$, F $^{3+}$ O C $^{3+}$ - . - . A , C /F - , - .

M (FE) A B_5FO_{15} (=4) $B_6F_2O_{18}$ (FM) (=5), B_4O_{12} , , BFO_3, FE FM .[12,13] B - , . [1–4] H , - C F B- , $B_5F_{0.5}C_{0.5}O_{15}$ - (=4) B_6FCO_{18} (=5) .[5] , - A $(B_2O_2)^{2+}(A_{-1}B_{}O_{3+1})^{2-}$ (A -, .[14,15] H , -, 12- - , B - , D -)[6] .[16] , - B- - A BFO_3 - .[7–11] .

I , A $B_{5.25}L_{0.75}FC_3O_{18}$ (BLFC) ( ). L , C , F , [14,17] D A a b , BLFC a b . A - , [18] .

A , *in situ* I H I I N , AL, D , O , K. F). , A BLFC . BLFC . , , . F 1 - (D) BLFC . A *B2cb* - A , $A2_1$, A [19,20] *B2cb* $a = 5.4530(2)$ A, $b = 5.4427(1)$ A, $c = 50.670(2)$ A - $A2_1am$ $a = 5.4651(6)$ A, $b = 5.3943(6)$ A, $c = 41.487(2)$ A F (:// . .).

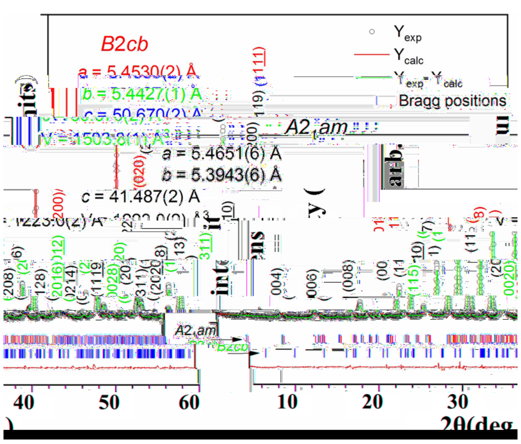

FIG. 1. - t , tt , t .

BLFC - A $=4$ $=5$. N D' . F 1 EM BLFC . - (a–b) . M , F . 1 . - 1.4 . %, D. ED (F . 2 1) F , C , O, . , C_2FO_4 - .

- A $B_5F_{0.5}C_{0.5}{}_3O_{15}$.[16] F 2( ) BLFC (50, 70 100, 300, 500 H). 1060 K FE T BLFC . H , BLFC $B_6{}_3F_2O_{18}$ (973 K).[13] F 2( ) P–E I–E BLFC . . I–E ,[21,22] . BLFC 10 μC/ ^{2}. F 2( ) - (FC) - (FC) 200 O BLFC . BLFC

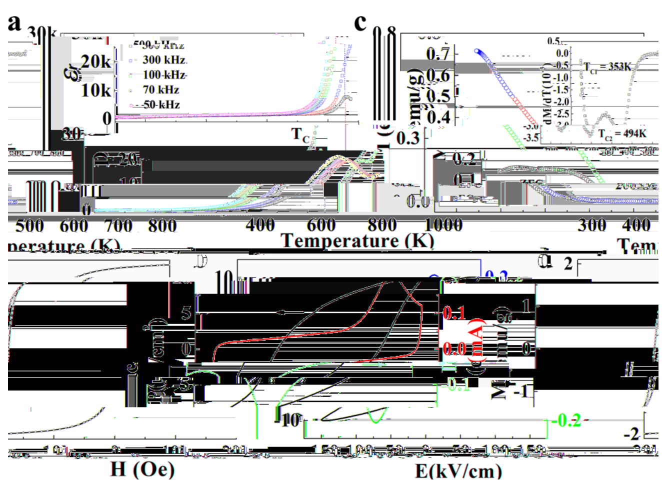

FIG. 2. ( ) t t t t t tt t ( ) t (,), = 200 t ( ) 300 t

$_1 \sim 494$ K
(M/),
$B_6FC_3O_{18}$ (526 K).[23]
BLFC
F^{3+} O F^{3+}, C^{3+} O C^{3+}, F^{3+} O C^{3+} (.
).[24]
ED .
A FC $_2 \sim 353$ K
C_2FO_4. $_2$
C_2FO_4 (460 K) .[16,25]
(M) C_2FO_4
16 23.5 / .[25] , 1.4 .%
C $_2$ F O_4 0.22 0.32 / ,
BLFC
M = 1.85 / , F . 2( ). I
, M H
$_1$
$_2$ (F . 3). .
425 K 1.58 / .
0.27 / ,
ED
. , BLFC
A .
F 3
F^{3+} O C^{3+}
(DF) *ab initio*
(A) . H
$_F = 2$ $_C = 3$ F C , ,
(GGA)+ . I
BLFC
F . 3( ), F^{3+} C^{3+} (3.1 2.1 μ_B/ ,),
O
(0.1 μ_B/).
F O_6 C O_6
( ) F /C
F O / . F . 3( ).
F ,
F^{3+} C^{3+} ,
(. .,) (. .,
) , .
, $E_{FM} - E_{AFM}$
= −144.1 .
H , . (FM)
43.5 (. ., 504.6 K), FM
$_1$ FC/FC . F . 2( ).
a b
. ,
010 .
F 4
BLFC . I
- , - ,

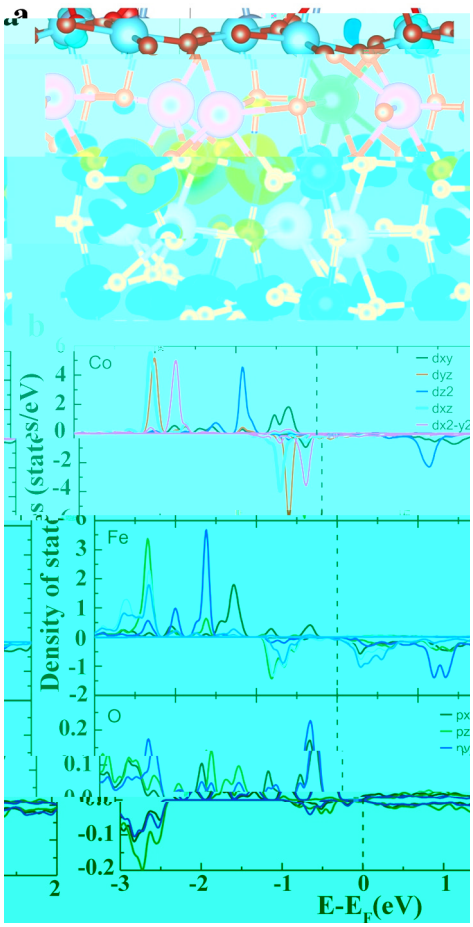

FIG. 3. ( ) t t tm (= 0.005) ( ), {),
( ), (t), ( ), ( ) tm . ( ) t
t t t t t t 3+ 3+.

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

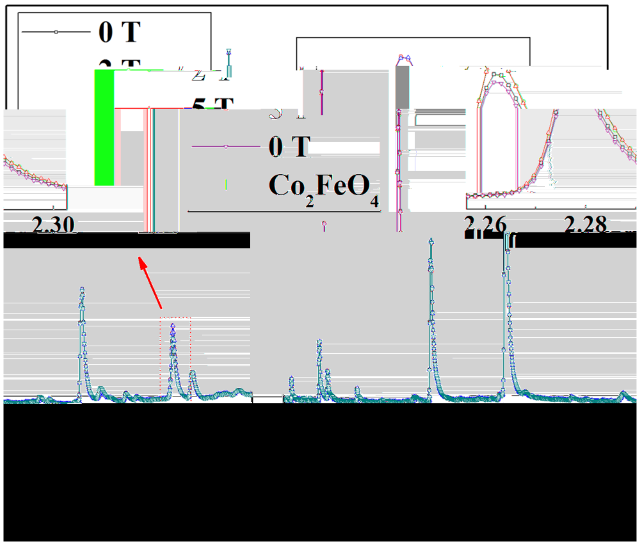

FIG. 4. (0, 2, 5 0).

C - ( ) +2000 O F . 5( ). −2000 O , F . 5( ). (-) C_2FO_4 - - - . , - , A BLFC . G (*P*) 100 (*M*) 010 , (-

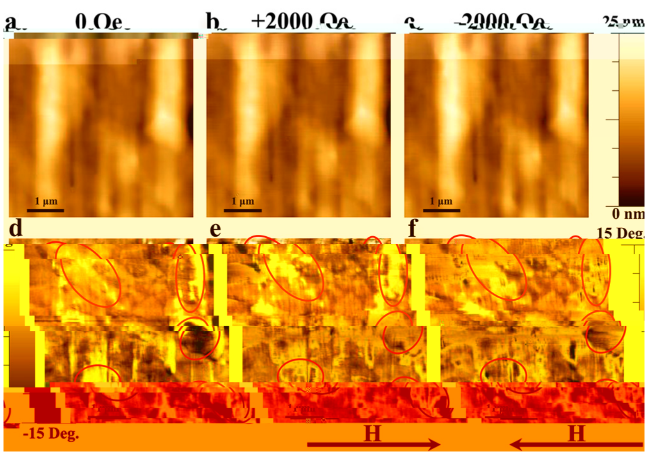

FIG. 5. ( ). ( ) ( ) 0 ( ) ( ) +2000 ( ) ( ) −2000 .

) $T = P \times M$ BLFC . I , A BLFC - . F F $^{3+}$ O F $^{3+}$, C $^{3+}$ O C $^{3+}$, F $^{3+}$ O C $^{3+}$ - . - . 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 EM E AME E .

DATA AVAILABILITY

.

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