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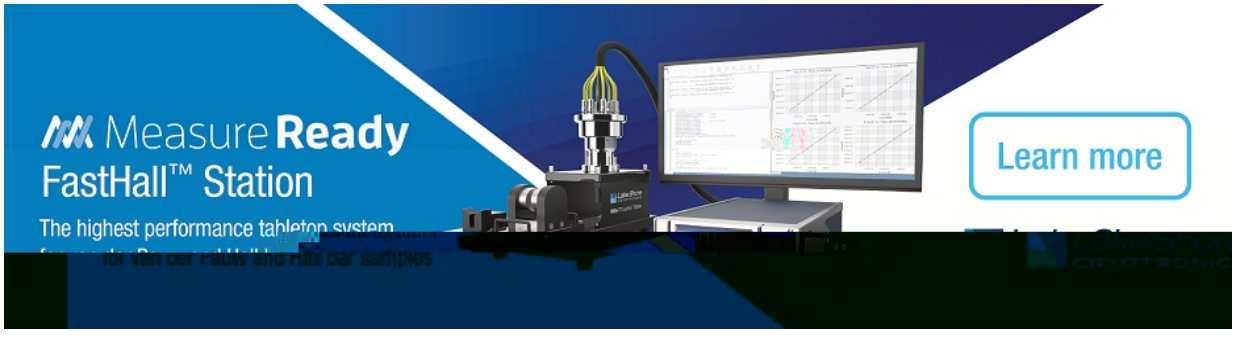

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Zheng Li,[1] Vladimir Koval,[2] Amit Mahajan,[3] Zhipeng Gao,[4] Carlo Vecchini,[5] Mark Stewart,[5] Markys G. Cain,[6] Kun Tao,[7] Chenglong Jia,[7,a)] Giuseppe Viola,[3] and Haixue Yan[3,b)]

AFFILIATIONS

[1]Gemological Institute, China University of Geosciences, Wuhan 430074, China
[2]Institute of Materials Research, Slovak Academy of Sciences, Watsonova 47, Kosice 04001, Slovakia
[3]School of Engineering and Materials Science, Queen Mary, University of London, London E1 4NS, United Kingdom
[4]National Key Laboratory of Shock Wave and Detonation Physics Institute of Fluid Physics, China Academy of Engineering Physics, Mianyang 621900, China
[5]National Physical Laboratory, Hampton Road, Teddington TW11 0LW, United Kingdom
[6]Electrosciences Ltd, Farnham, Surrey GU9 9QT, United Kingdom
[7]School of Physical Science and Technology, Lanzhou University, Lanzhou 730000, China

[a)]Email: cljia@lzu.edu.cn
[b)]Author to whom correspondence should be addressed: h.x.yan@qmul.ac.uk

ABSTRACT

M . H , A D . H , A B5.25L0.75F C 3O18 *in situ* A , C /F - F 3+ O F 3+, C 3+ O C 3+, F 3+ O C 3+ , A .

M (FE) (FM) , . [1 4] H , - A [5] , (B 2O2)2+(A -1B O3 +1)2− (A -, 12- , B) [6] B- BF O3 - [7 11] . A B5F 3O15 (=4) B6F 2 3O18 (=5), BF O3, C F B- , (=4) B6F C 3O18 (=5) [14,15] H , D - [16] , A .

I A B 5.25 L 0.75 F C 3 O 18 (BLFC) ( ). L

C , [14,17] D F , 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*$_1$*am* $a = 5.4651(6)$ A, $b = 5.3943(6)$ A, $c = 41.487(2)$ A F (:// . .).

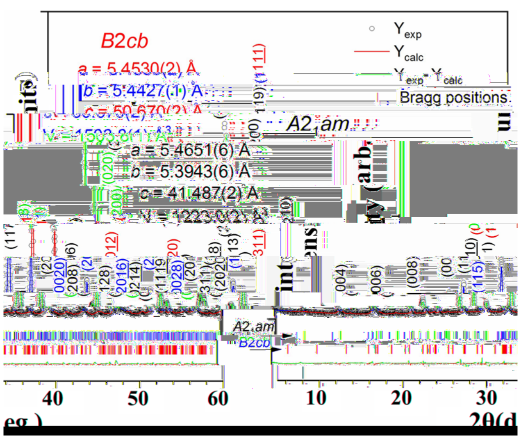

FIG. 1. -

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 2 F O 4 A B 5 F 0.5 C 0.5 3 O 15.[16] F 2( ) BLFC (50, 70, 100, 300, 500 H). 1060 K FE *T* BLFC . H BLFC B 6 3 F 2 O 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

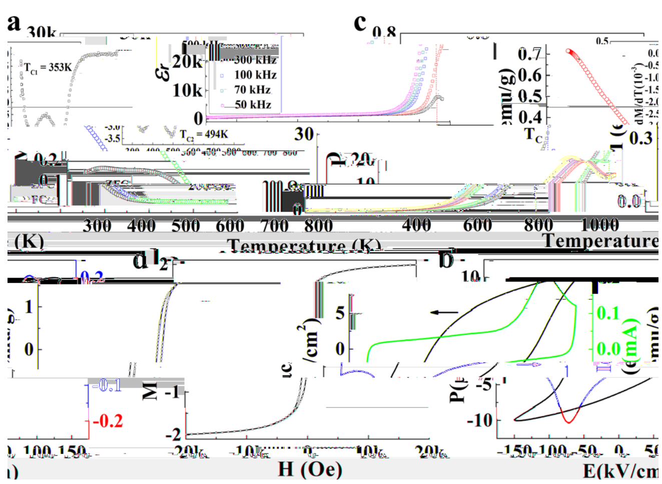

FIG. 2. ( ) = 200 300

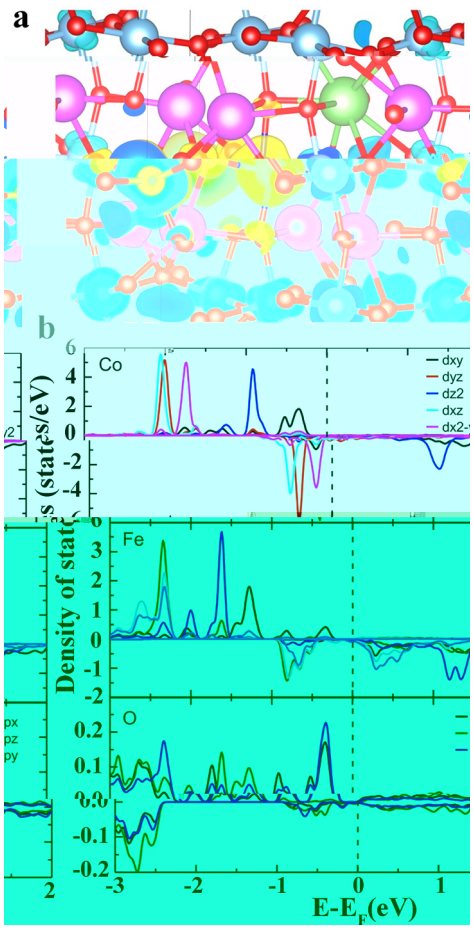

FIG. 3. ( ) t t tm (=0.005) ( ), {), ( ), (t), ( ), ( ) tm . ( ) t t t t t t t 3+ 3+.

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

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117, 052 03-3

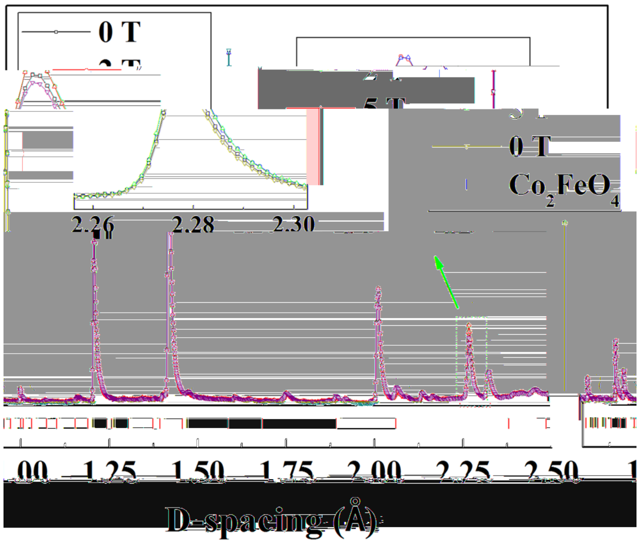

FIG. 4. (0, 2, 5 , 0).

C ( ) +2000 O F . 5( ) . −2000 O F . 5( ). ( ) Co_2FeO_4 A BLFC . G (P) 100 (M) 010 (

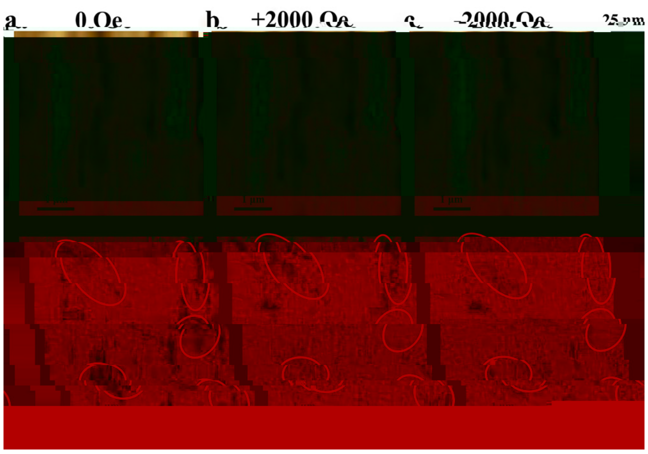

FIG. 5. ( ). ( ) ( ) t 0 ( ) ( ) +2000 ( ) ( ) −2000 .

) $T = P \times M$ 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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REFERENCES

[1] . E , N. D. M , J. F. , N 442, 759 (2006).
[2] . N. A. , N . M . 6, 21 (2007).
[3] J. M , J. H , . L , C. . N , A . M . 23, 1062 (2011).
[4] L. F. H , O. C , J. B , J. L , . , C. H H , . H , O. G , D. C. L , H. , . K , A. J. B , A . F . M . 26, 2111 (2016).
[5] N. A. H , J. . C . B 104, 6694 (2000).
[6] B. A , M : II. B 4 3O12, A . K 1(58), 499 512 (1949).
[7] A. , . , G. K , M. M. K , J. .: C . M . 11, 3335 (1999).
[8] N. . G. . K , M . . E ., B 108, 194 (2004).
[9] L. K , . M , M. , A. A , N. D , N. , . , M. E. , . . D. J , J. A . C . 96, 2339 (2013).
[10] . L , J. M , . G , G. , . K , A. M , . L , C. J , C. N , H. , D . 45, 14049 (2016).
[11] J. F. , N G A M . 5, 72 (2013).
[12] A. . B C. E , . B 90, 214109 (2014).
[13] J. B. L , . H , G. H. , G. . L , J. L , J. . C , J. K. L , A . L . 96, 222903 (2010).
[14] . M , . , C , . L , A . L . 95, 082901 (2009).
[15] . L , J. , . , L. , . , J. D , . , A . L . 101, 122402 (2012).

[16]M. a a , . . C , M. B. a , A. . B a , J. . H a , . K a , L. K , . , M. , . a , C. , . H. K , a A. J. B a , J. A . . **112**, 073919 (2012).
[17]J. L , . , H. a , M. J. , . K a , a a , . a , J. A . . **102**, 104107 (2007).
[18]M. G. C a , *Characterisation of Ferroelectric Bulk Materials and Thin Films* (, 2014), . 2.
[19]. L a , K. a , J. M a , . G a a , . K a , C. J a , G. a , H. a , A. M a a a , J. C a , M. C a , I. A a a , C. N a , C. J , a H. , J. M a . C . C **6**, 2733 (2018).
[20]. K a , I. a , G. a , M. a , C. J a a , H. a , J. . C . C **122**, 15733 (2018).
[21]L. J a F. L , a . a , J. A . C a . a **97**, 1 (2014).
[22]H. a , F. I a , G. a , H. N , H. a , . J a , . , . G a , a M. J. a , J. A . D . **1**, 107 (2011).
[23]J. a , L. , . L , . , . , J. D a , . a , a . , A . . L . **101**, 012402 (2012).
[24]B. a , J. a , J. C , . , L. , . a , . , J. D a , . , a . , A . . L . **104**, 062413 (2014).
[25]I. . M a a . N. B , . a . . **11**, 719 (2009).