Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Electronic Supplementary Information (ESI)

Cryogenic Magnetocaloric Effect in Distorted Double-perovskite Gd_2ZnTiO_6

Ziyu Yang,[a, b] Jun-Yi Ge,[c] Shuangchen Ruan,[a] Hongzhi Cui[*b] and Yu-Jia Zeng[*a]

Affiliations

[a] College of Physics and Optoelectronic Engineering, Shenzhen University, 518060, Shenzhen, China.

[b] Key Laboratory for Resilient Infrastructures of Coastal Cities (MOE), College of Civil and Transportation Engineering, Shenzhen University, 518060, Shenzhen, China.

[c] Materials Genome Institute, Shanghai University, 200444, Shanghai, China.

Correspondence: yjzeng@szu.edu.cn, h.z.cui@szu.edu.cn.

1 Experimental Section

Structural Analysis. The products were investigated by powder X-ray diffraction patterns collected on a Rigaku Ultimate IV diffractometer equipped with Cu-*Kα* radiation at room temperature. A Rietveld analysis was performed using the GSAS package with the *EXPGUI* interface.[1-3] The backgrounds and peak shape were modeled by the first kind of Chebyshev polynomial and pseudo-Voigt function.

Physical Measurements. The magnetic susceptibility and magnetization data were collected in the Physical Property Measurement System (PPMS®DynaCool™, Quantum Design) with an applied field of 20 mT in the 2-300 K temperature range. Isothermal magnetization curves were collected in the field range ≤7 T and temperature range of 2-11 K with a step of 1 K after cooling in zero fields.

Heat capacity measurements were conducted using the thermal-relaxation method on powder samples in a commercial setup Physical Property Measurement System (PPMS-9, Quantum Design) with Apiezon N-grease, under a temperature range of 1.9-30 K and constant external fields of 0, 2, 7, and 9 T, respectively.

2 Supplementary tables

Table S1 Selected interatomic length values of Gd_2ZnTiO_6.

Vector	Length	Optr Cell	Neighbor atom coordinates
Gd1_Gd1	3.7863(20)	2 1-1 0	0.98415 0.06532 0.25302
Gd1_Gd1	3.7863(20)	2 1 0 0	0.98415 1.06532 0.25302
Gd1_Gd1	3.870(6)	-1 1 1 0	0.48415 0.43468 -0.24698
Gd1_Gd1	3.963(6)	-1 1 1 1	0.48415 0.43468 0.75302
Gd1_O1	2.728(12)	2 0 0 0	0.30294 0.69262 0.55467
Gd1_O1	2.542(13)	-1 1 1 0	0.80294 0.80738 0.05467
Gd1_O1	2.321(11)	-2 1 1 1	0.69706 0.30738 0.44533
Gd1_O2	2.661(12)	1 0 0 0	0.31569 0.70776 -0.05265
Gd1_O2	2.335(11)	-1 1 1 0	0.68431 0.29224 0.05265
Gd1_O2	2.566(13)	-2 1 2 1	0.81569 0.79224 0.44735
Gd1_O3	2.366(6)	1 0 1 0	0.39080 0.96569 0.23940
Gd1_O3	2.257(8)	2 0 0 0	0.10920 0.46569 0.26060
Gd1_Ti1	3.1096(19)	1 0 1 0	0.50000 1.00000 0.00000
Gd1_Ti1	3.4110(17)	2 0 0 0	0.00000 0.50000 0.50000
Gd1_Ti1	3.2582(25)	2 1 0 0	1.00000 0.50000 0.50000
Gd1_Zn1	3.3687(24)	1 0 0 0	0.00000 0.50000 0.00000
Gd1_Zn1	3.2464(17)	1 1 0 0	1.00000 0.50000 0.00000
Gd1_Zn1	3.1387(19)	2 0 0 0	0.50000 1.00000 0.50000
Ti1_Gd1	3.1096(19)	1 0-1 0	0.51585 -0.43468 0.24698
Ti1_Gd1	3.4110(17)	2 0-1 0	-0.01585 0.06532 0.25302
Ti1_Gd1	3.2582(25)	2 1-1 0	0.98415 0.06532 0.25302
Ti1_Gd1	3.1096(19)	-1 1 1 0	0.48415 0.43468 -0.24698
Ti1_Gd1	3.2582(25)	-2 0 1 0	0.01585 -0.06532 -0.25302
Ti1_Gd1	3.4110(17)	-2 1 1 0	1.01585 -0.06532 -0.25302
Ti1_O1	2.001(12)	1 0 0 0	0.19706 0.19262 -0.05467

Ti1_O1	2.001(12)	-1 1 0 0	0.80294	-0.19262	0.05467
Ti1_O2	1.969(12)	1 0-1 0	0.31569	-0.29224	-0.05265
Ti1_O2	1.969(12)	-1 1 1 0	0.68431	0.29224	0.05265
Ti1_O3	1.943(13)	1 0 0 0	0.39080	-0.03431	0.23940
Ti1_O3	1.943(13)	-1 1 0 0	0.60920	0.03431	-0.23940
Zn1_Gd1	3.2464(17)	1-1 0 0	-0.48415	0.56532	0.24698
Zn1_Gd1	3.3687(24)	1 0 0 0	0.51585	0.56532	0.24698
Zn1_Gd1	3.1387(19)	2 0-1 0	-0.01585	0.06532	0.25302
Zn1_Gd1	3.3687(24)	-1 0 1 0	-0.51585	0.43468	-0.24698
Zn1_Gd1	3.2464(17)	-1 1 1 0	0.48415	0.43468	-0.24698
Zn1_Gd1	3.1387(19)	-2 0 2 0	0.01585	0.93468	-0.25302
Zn1_O1	2.081(13)	1 0 0 0	0.19706	0.19262	-0.05467
Zn1_O1	2.081(13)	-1 0 1 0	-0.19706	0.80738	0.05467
Zn1_O2	2.104(12)	1 0 0 0	0.31569	0.70776	-0.05265
Zn1_O2	2.104(12)	-1 0 1 0	-0.31569	0.29224	0.05265
Zn1_O3	2.093(13)	2 0 0 0	0.10920	0.46569	0.26060
Zn1_O3	2.093(13)	-2 0 1 0	-0.10920	0.53431	-0.26060

Table S2 Selected bond angles of Gd_2ZnTiO_6.

Angle	Degrees	atom 1 loc	atom 3	loc
O1_Gd1_O1	117.92(22)	-1 1 1	0	-2 1 1 1
O1_Gd1_O2	64.9(4)	-1 1 1	0	1 0 0 0
O1_Gd1_O2	75.4(5)	-1 1 1	0	-1 1 1 0
O1_Gd1_O2	72.47(21)	-1 1 1	0	-2 1 2 1
O1_Gd1_O3	69.0(4)	-1 1 1	0	1 0 1 0
O1_Gd1_O3	138.7(4)	-1 1 1	0	2 0 0 0
O1_Gd1_Ti1	39.90(28)	-1 1 1	0	1 0 1 0
O1_Gd1_Ti1	85.67(25)	-1 1 1	0	2 1 0 0
O1_Gd1_Zn1	87.45(26)	-1 1 1	0	2 0 0 0
O1_Gd1_O2	157.7(5)	-2 1 1	1	1 0 0 0
O1_Gd1_O2	80.84(29)	-2 1 1	1	-1 1 1 0
O1_Gd1_O2	70.2(5)	-2 1 1	1	-2 1 2 1
O1_Gd1_O3	137.5(5)	-2 1 1	1	1 0 1 0
O1_Gd1_O3	102.4(4)	-2 1 1	1	2 0 0 0
O1_Gd1_Ti1	155.39(31)	-2 1 1	1	1 0 1 0
O1_Gd1_Ti1	37.49(31)	-2 1 1	1	2 1 0 0
O1_Gd1_Zn1	95.7(4)	-2 1 1	1	2 0 0 0
O2_Gd1_O2	78.7(5)	1 0 0	0	-1 1 1 0
O2_Gd1_O2	128.05(17)	1 0 0	0	-2 1 2 1
O2_Gd1_O3	64.8(4)	1 0 0	0	1 0 1 0
O2_Gd1_O3	74.3(4)	1 0 0	0	2 0 0 0
O2_Gd1_Ti1	38.93(27)	1 0 0	0	1 0 1 0
O2_Gd1_Ti1	150.22(25)	1 0 0	0	2 1 0 0
O2_Gd1_Zn1	106.63(25)	1 0 0	0	2 0 0 0
O2_Gd1_O2	118.16(24)	-1 1 1	0	-2 1 2 1
O2_Gd1_O3	136.9(5)	-1 1 1	0	1 0 1 0
O2_Gd1_O3	104.0(4)	-1 1 1	0	2 0 0 0

O2_Gd1_Ti1	98.25(33)	-1 1 1	0	1 0 1 0
O2_Gd1_Ti1	89.79(31)	-1 1 1	0	2 1 0 0
O2_Gd1_Zn1	158.05(29)	-1 1 1	0	2 0 0 0
O2_Gd1_O3	73.2(4)	-2 1 2	1	1 0 1 0
O2_Gd1_O3	134.5(4)	-2 1 2	1	2 0 0 0
O2_Gd1_Ti1	89.13(25)	-2 1 2	1	1 0 1 0
O2_Gd1_Ti1	37.18(28)	-2 1 2	1	2 1 0 0
O2_Gd1_Zn1	41.78(26)	-2 1 2	1	2 0 0 0
O3_Gd1_O3	88.09(17)	1 0 1	0	2 0 0 0
O3_Gd1_Ti1	38.66(31)	1 0 1	0	1 0 1 0
O3_Gd1_Ti1	110.41(26)	1 0 1	0	2 1 0 0
O3_Gd1_Zn1	41.82(31)	1 0 1	0	2 0 0 0
O3_Gd1_Ti1	101.70(25)	2 0 0	0	1 0 1 0
O3_Gd1_Ti1	135.41(33)	2 0 0	0	2 1 0 0
O3_Gd1_Zn1	97.94(26)	2 0 0	0	2 0 0 0
Ti1_Gd1_Ti1	118.26(4)	1 0 1	0	2 1 0 0
Ti1_Gd1_Zn1	75.897(18)	1 0 1	0	2 0 0 0
Ti1_Gd1_Zn1	75.13(6)	2 1 0	0	2 0 0 0
Gd1_O1_Gd1	102.2(4)	-1 1 1	0	-2 0 1 0
Gd1_O1_Ti1	85.5(4)	-1 1 1	0	1 0 0 0
Gd1_O1_Zn1	88.6(5)	-1 1 1	0	1 0 0 0
Gd1_O1_Ti1	97.6(5)	-2 0 1	0	1 0 0 0
Gd1_O1_Zn1	116.6(5)	-2 0 1	0	1 0 0 0
Ti1_O1_Zn1	145.8(6)	1 0 0	0	1 0 0 0
Gd1_O2_Gd1	101.3(5)	1 0 0	0	-1 1 1 0
Gd1_O2_Gd1	156.9(4)	1 0 0	0	-2 0 2 0
Gd1_O2_Ti1	82.9(4)	1 0 0	0	1 0 1 0
Gd1_O2_Zn1	89.2(4)	1 0 0	0	1 0 0 0
Gd1_O2_Gd1	101.0(4)	-1 1 1	0	-2 0 2 0

Gd1_O2_Ti1	119.5(5)	-1 1 1	0	1 0 1 0
Gd1_O2_Zn1	93.9(5)	-1 1 1	0	1 0 0 0
Gd1_O2_Ti1	90.9(5)	-2 0 2	0	1 0 1 0
Gd1_O2_Zn1	83.8(4)	-2 0 2	0	1 0 0 0
Ti1_O2_Zn1	146.6(5)	1 0 1	0	1 0 0 0
Gd1_O3_Gd1	120.85(33)	1 0-1	0	2 0-1 0
Gd1_O3_Ti1	91.9(4)	1 0-1	0	1 0 0 0
Gd1_O3_Zn1	89.3(4)	1 0-1	0	2 0-1 0
Gd1_O3_Ti1	108.4(5)	2 0-1	0	1 0 0 0
Gd1_O3_Zn1	101.4(5)	2 0-1	0	2 0-1 0
Ti1_O3_Zn1	144.3(4)	1 0 0	0	2 0-1 0
Gd1_Ti1_Gd1	72.926(28)	1 0-1	0	2 1-1 0
Gd1_Ti1_Gd1	180.000(0)	1 0-1	0	-1 1 1 0
Gd1_Ti1_Gd1	107.074(28)	1 0-1	0	-2 0 1 0
Gd1_Ti1_O1	125.4(4)	1 0-1	0	1 0 0 0
Gd1_Ti1_O1	54.6(4)	1 0-1	0	-1 1 0 0
Gd1_Ti1_O2	58.1(4)	1 0-1	0	1 0-1 0
Gd1_Ti1_O2	121.9(4)	1 0-1	0	-1 1 1 0
Gd1_Ti1_O3	49.49(18)	1 0-1	0	1 0 0 0
Gd1_Ti1_O3	130.51(18)	1 0-1	0	-1 1 0 0
Gd1_Ti1_Gd1	107.074(28)	2 1-1	0	-1 1 1 0
Gd1_Ti1_Gd1	180.000(0)	2 1-1	0	-2 0 1 0
Gd1_Ti1_O1	135.07(32)	2 1-1	0	1 0 0 0
Gd1_Ti1_O1	44.93(32)	2 1-1	0	-1 1 0 0
Gd1_Ti1_O2	128.0(4)	2 1-1	0	1 0-1 0
Gd1_Ti1_O2	52.0(4)	2 1-1	0	-1 1 1 0
Gd1_Ti1_O3	71.93(26)	2 1-1	0	1 0 0 0
Gd1_Ti1_O3	108.07(26)	2 1-1	0	-1 1 0 0
Gd1_Ti1_Gd1	72.926(28)	-1 1 1	0	-2 0 1 0

Gd1_Ti1_O1	54.6(4)	-1 1 1	0	1 0 0 0
Gd1_Ti1_O1	125.4(4)	-1 1 1	0	-1 1 0 0
Gd1_Ti1_O2	121.9(4)	-1 1 1	0	1 0-1 0
Gd1_Ti1_O2	58.1(4)	-1 1 1	0	-1 1 1 0
Gd1_Ti1_O3	130.51(18)	-1 1 1	0	1 0 0 0
Gd1_Ti1_O3	49.49(18)	-1 1 1	0	-1 1 0 0
Gd1_Ti1_O1	44.93(32)	-2 0 1	0	1 0 0 0
Gd1_Ti1_O1	135.07(32)	-2 0 1	0	-1 1 0 0
Gd1_Ti1_O2	52.0(4)	-2 0 1	0	1 0-1 0
Gd1_Ti1_O2	128.0(4)	-2 0 1	0	-1 1 1 0
Gd1_Ti1_O3	108.07(26)	-2 0 1	0	1 0 0 0
Gd1_Ti1_O3	71.93(26)	-2 0 1	0	-1 1 0 0
O1_Ti1_O1	180.000(0)	1 0 0	0	-1 1 0 0
O1_Ti1_O2	90.5(6)	1 0 0	0	1 0-1 0
O1_Ti1_O2	89.5(6)	1 0 0	0	-1 1 1 0
O1_Ti1_O3	90.3(4)	1 0 0	0	1 0 0 0
O1_Ti1_O3	89.7(4)	1 0 0	0	-1 1 0 0
O1_Ti1_O2	89.5(6)	-1 1 0	0	1 0-1 0
O1_Ti1_O2	90.5(6)	-1 1 0	0	-1 1 1 0
O1_Ti1_O3	89.7(4)	-1 1 0	0	1 0 0 0
O1_Ti1_O3	90.3(4)	-1 1 0	0	-1 1 0 0
O2_Ti1_O2	180.000(0)	1 0-1	0	-1 1 1 0
O2_Ti1_O3	87.5(4)	1 0-1	0	1 0 0 0
O2_Ti1_O3	92.5(4)	1 0-1	0	-1 1 0 0
O2_Ti1_O3	92.5(4)	-1 1 1	0	1 0 0 0
O2_Ti1_O3	87.5(4)	-1 1 1	0	-1 1 0 0
O3_Ti1_O3	180.000(0)	1 0 0	0	-1 1 0 0
Gd1_Zn1_Gd1	180.000(0)	2 0-1	0	-2 0 2 0
Gd1_Zn1_O1	58.9(4)	2 0-1	0	1 0 0 0

Gd1_Zn1_O1	121.1(4)	2 0-1	0	-1 0 1 0
Gd1_Zn1_O2	125.62(35)	2 0-1	0	1 0 0 0
Gd1_Zn1_O2	54.38(35)	2 0-1	0	-1 0 1 0
Gd1_Zn1_O3	48.90(18)	2 0-1	0	2 0 0 0
Gd1_Zn1_O3	131.10(18)	2 0-1	0	-2 0 1 0
Gd1_Zn1_O1	121.1(4)	-2 0 2	0	1 0 0 0
Gd1_Zn1_O1	58.9(4)	-2 0 2	0	-1 0 1 0
Gd1_Zn1_O2	54.38(35)	-2 0 2	0	1 0 0 0
Gd1_Zn1_O2	125.62(35)	-2 0 2	0	-1 0 1 0
Gd1_Zn1_O3	131.10(18)	-2 0 2	0	2 0 0 0
Gd1_Zn1_O3	48.90(18)	-2 0 2	0	-2 0 1 0
O1_Zn1_O1	180.000(0)	1 0 0	0	-1 0 1 0
O1_Zn1_O2	91.1(6)	1 0 0	0	1 0 0 0
O1_Zn1_O2	88.9(6)	1 0 0	0	-1 0 1 0
O1_Zn1_O3	88.6(4)	1 0 0	0	2 0 0 0
O1_Zn1_O3	91.4(4)	1 0 0	0	-2 0 1 0
O1_Zn1_O2	88.9(6)	-1 0 1	0	1 0 0 0
O1_Zn1_O2	91.1(6)	-1 0 1	0	-1 0 1 0
O1_Zn1_O3	91.4(4)	-1 0 1	0	2 0 0 0
O1_Zn1_O3	88.6(4)	-1 0 1	0	-2 0 1 0
O2_Zn1_O2	180.000(0)	1 0 0	0	-1 0 1 0
O2_Zn1_O3	90.8(4)	1 0 0	0	2 0 0 0
O2_Zn1_O3	89.2(4)	1 0 0	0	-2 0 1 0
O2_Zn1_O3	89.2(4)	-1 0 1	0	2 0 0 0
O2_Zn1_O3	90.8(4)	-1 0 1	0	-2 0 1 0
O3_Zn1_O3	180.000(0)	2 0 0	0	-2 0 1 0

Table S3 State of the art collections of solid-state cryogenic refrigeration (CR) materials.

Formula	$-\Delta S_M$/ $J\cdot K^{-1}\cdot Kg^{-1}$	$-\Delta S_M$/ $mJ\cdot K^{-1}\cdot cm^{-3}$	T/ K	ΔH/ T	*Ref*
Gd_3BWO_9	58.1	452	2	9	[36]
Gd_2ZnTiO_6	53.5	398.7	3.1	9	**This work**
$GdBO_3$	57.8	366.3	2	9	[26]
$GdAlO_3$	40.9	317	2	9	[22]
$GdCrO_3$	41.24	303	4	9	[32]
$[Gd(HCOO)(bdc)]_n$	47	125	2	9	[8]
$[Gd(C_4O_4)(OH)(H_2O)_4]_n$	47.3	112.7	3	9	[10]
$K_2Gd(BH_4)_5$	54.6	59.8	5	9	[24]
$EuHo_2O_4$	30	267	2	8	[33]
$EuDy_2O_4$	25	224	2	8	[33]
$Gd_2Cu(SO_4)_2(OH)_4$	45.52	212.8	4	8	[17]
GdF_3	71	506	3	7	[20]
$Gd_5BSi_2O_{13}$	67	461	3	7	[27]
$GdPO_4$	62	375.8	2	7	[21]
$Gd(OH)CO_3$	66.4	355	2	7	[4]
$Gd(OH)_3$	62	346.08	2	7	[16]
$EuTiO_3$	49	331	5	7	[29]
$GdFeO_3$	44	321	3	7	[35]
$[Gd_3(OH)_8Cl]_n$	61.8	318.9	3	7	[19]
$K_3Li_3Gd_7(BO_3)_9$	56.6	277.2	2	7	[25]
$Gd(OH)SO_4$	53.5	276	2	7	[18]
Gd_2NiMnO_6	35.5	268	4	7	[31]
$Gd(HCOO)_3$	55.9	215.7	2	7	[5]
$\{[Gd_6O(OH)_8(ClO_4)_4(H_2O)_6](OH)_4\}_n$	46.6	215.6	3	7	[6]
$[Gd_4(SO_4)_4(\mu_3\text{-}OH)_4(H_2O)]_n$	51.3	198.9	2	7	[7]
$[Gd_{48}O_6(OH)_{84}(CAA)_{36}(NO_3)_6(H_2O)_{24}(EtOH)_{12}(NO_3)Cl_2]Cl_3\cdot 6DMF\cdot 5EtOH\cdot 20H_2O$	43.6	120.7	2	7	[9]
$[MnII(glc)_2(H_2O)_2]$	60.3	112	2	7	[11]
$[Gd(HCOO)(OAc)_2(H_2O)_2]_n$	45.9	110	2	7	[12]
$[Gd(OAc)_3(H_2O)_{0.5}]_n$	47.7	106.3	2	7	[13]
$\{[Gd_2(IDA)_3]\cdot 2H_2O\}_n$	40.6	100.7	2	7	[14]
$\{[Gd_{36}O_6(OH)_{49}(NA)_{36}(NO_3)_6(N_3)_3(H_2O)_{20}]Cl_2\cdot 28H_2O\}_n$	39.66	91.3	3	7	[15]
$GdCrTiO_5$	36	\	5	7	[28]
$GdFeTeO_6$	38.5	\	5	7	[34]

EuSe	37.5	244.8	5	5	[30]
$GdVO_4$	41.1	227	3	5	[23]

References

[1] H. Rietveld, *J. Appl. Crystallogr.*, 1969, **2**, 65-71.

[2] B. Toby, *J. Appl. Crystallogr.*, 2001, **34**, 210-213.

[3] A. C. Larson and R. B. Von Dreele, *Report LAUR*, 1994, 86-748.

[4] Y.-C. Chen, L. Qin, Z.-S. Meng, D.-F. Yang, C. Wu, Z. Fu, Y.-Z. Zheng, J.-L. Liu, R. Tarasenko, M. Orendáč, J. Prokleška, V. Sechovský and M.-L. Tong, *J. Mater. Chem. A*, 2014, **2**, 9851-9858.

[5] G. Lorusso, J. W. Sharples, E. Palacios, O. Roubeau, E. K. Brechin, R. Sessoli, A. Rossin, F. Tuna, E. J. L. McInnes, D. Collison and M. Evangelisti, *Adv. Mater.*, 2013, **25**, 4653-4656.

[6] Y.-L. Hou, G. Xiong, P.-F. Shi, R.-R. Cheng, J.-Z. Cui and B. Zhao, *Chem. Commun.*, 2013, **49**, 6066-6068.

[7] S.-D. Han, X.-H. Miao, S.-J. Liu and X.-H. Bu, *Inorg. Chem. Front.*, 2014, **1**, 549-552.

[8] R. Sibille, T. Mazet, B. Malaman and M. François, *Chem. - Eur. J.*, 2012, **18**, 12970-12973.

[9] F.-S. Guo, Y.-C. Chen, L.-L. Mao, W.-Q. Lin, J.-D. Leng, R. Tarasenko, M. Orendáč, J. Prokleška, V. Sechovský and M.-L. Tong, *Chem. - Eur. J.*, 2013, **19**, 14876-14885.

[10] S. Biswas, A. Adhikary, S. Goswami and S. Konar, *Dalton Trans.*, 2013, **42**, 13331-13334.

[11] Y.-C. Chen, F.-S. Guo, J.-L. Liu, J.-D. Leng, P. Vrábel, M. Orendáč, J. Prokleška, V. Sechovský and M.-L. Tong, *Chem. - Eur. J.*, 2014, **20**, 3029-3035.

[12] G. Lorusso, M. A. Palacios, G. S. Nichol, E. K. Brechin, O. Roubeau and M. Evangelisti, *Chem. Commun.*, 2012, **48**, 7592-7594.

[13] F.-S. Guo, J.-D. Leng, J.-L. Liu, Z.-S. Meng and M.-L. Tong, *Inorg. Chem.*, 2012, **51**, 405-413.

[14] J.-M. Jia, S.-J. Liu, Y. Cui, S.-D. Han, T.-L. Hu and X.-H. Bu, *Cryst. Growth Des.*, 2013, **13**, 4631-4634.

[15] M. Wu, F. Jiang, X. Kong, D. Yuan, L. Long, S. A. Al-Thabaiti and M. Hong, *Chem. Sci.*, 2013, **4**, 3104-3109.

[16] Y. Yang, Q.-C. Zhang, Y.-Y. Pan, L.-S. Long and L.-S. Zheng, *Chem. Commun.*, 2015, **51**, 7317-7320.

[17] Y. Tang, W. Guo, S. Zhang, M. Yang, H. Xiang and Z. He, *Dalton Trans.*, 2015, **44**, 17026-17029.

[18] Y. Han, S.-D. Han, J. Pan, Y.-J. Ma and G.-M. Wang, *Mater. Chem. Front.*, 2018, **2**, 2327-2332.

[19] Y. Wang, L. Qin, G.-J. Zhou, X. Ye, J. He and Y.-Z. Zheng, *J. Mater. Chem. C*, 2016, **4**, 6473-6477.

[20] Y.-C. Chen, J. Prokleška, W.-J. Xu, J.-L. Liu, J. Liu, W.-X. Zhang, J.-H. Jia, V. Sechovský and M.-L. Tong, *J. Mater. Chem. C*, 2015, **3**, 12206-12211.

[21] E. Palacios, J. A. Rodríguez-Velamazán, M. Evangelisti, G. J. McIntyre, G. Lorusso, D. Visser, L. J. de Jongh and L. A. Boatner, *Phys. Rev. B*, 2014, **90**, 214423-214423.

[22] S. Mahana, U. Manju and D. Topwal, *J. Phys. D: Appl. Phys.*, 2016, **50**, 035002.

[23] K. Dey, A. Indra, S. Majumdar and S. Giri, *J. Mater. Chem. C*, 2017, **5**, 1646-1650.

[24] P. Schouwink, E. Didelot, Y.-S. Lee, T. Mazet and R. Černý, *J. Alloys Compd.*, 2016, **664**, 378-384.

[25] M. Xia, S. Shen, J. Lu, Y. Sun and R. Li, *Chem. - Eur. J.*, 2018, **24**, 3147-3150.

[26] P. Mukherjee, Y. Wu, G. I. Lampronti and S. E. Dutton, *Mater. Res. Bull.*, 2018, **98**, 173-179.

[27] C. Tao and R. Li, *Chem. - Asian J.*, 2018, **13**, 2834-2837.

[28] M. Das, S. Roy, N. Khan and P. Mandal, *Phys. Rev. B*, 2018, **98**, 104420-104420.

[29] A. Midya, P. Mandal, K. Rubi, R. Chen, J.-S. Wang, R. Mahendiran, G. Lorusso and M. Evangelisti, *Phys. Rev. B*, 2016, **93**, 094422-094422.

[30] D. X. Li, T. Yamamura, S. Nimori, Y. Homma, F. Honda and D. Aoki, *Appl. Phys. Lett.*, 2013, **102**, 152409-152409.

[31] J. K. Murthy, K. D. Chandrasekhar, S. Mahana, D. Topwal and A. Venimadhav, *J. Phys. D: Appl. Phys.*, 2015, **48**, 355001.

[32] S. Mahana, U. Manju and D. Topwal, *J. Phys. D: Appl. Phys.*, 2018, **51**, 305002.

[33] A. Midya, N. Khan, D. Bhoi and P. Mandal, *Appl. Phys. Lett.*, 2012, **101**, 132415-132415.

[34] D. D. Lei, Z. W. Ouyang, X. Y. Yue, L. Yin, Z. X. Wang, J. F. Wang, Z. C. Xia and G. H. Rao, *J. Appl. Phys.*, 2018, **124**, 233904-233904.

[35] M. Das, S. Roy and P. Mandal, *Phys. Rev. B*, 2017, **96**, 174405.

[36] Z. Yang, H. Zhang, M. Bai, W. Li, S. Huang, S. Ruan and Y. Zeng, *J. Mater. Chem. C*, 2020, 8, 11866-11873.