

รายการอ้างอิง

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ภาคผนวก

ภาคผนวก ก.

การคำนวณค่าแลตทิซพารามิเตอร์ (Lattice Parameter)

และความหนาแน่นทางทฤษฎี

เนื่องจากชิ้นงานที่ได้มีลักษณะโครงสร้างเป็นแบบเตตระโกนอล ซึ่งสามารถที่จะคำนวณหาปริมาตรของชิ้นงานตามทฤษฎีโดยใช้สมการ

$$V = a^2 c$$

เมื่อ a และ c คือค่าแลตทิซพารามิเตอร์ (Lattice parameters) ในกรณีนี้ใช้ค่าแลตทิซพารามิเตอร์ที่พีค (200) และ (002)

สำหรับค่าแลตทิซพารามิเตอร์คำนวณได้จากสมการ

$$\frac{1}{d_{hkl}^2} = \frac{h^2 + k^2}{a^2} + \frac{l^2}{c^2}$$

ที่พีค (200) มุม 2θ 45 องศา

$$\frac{1}{d_{200}^2} = \frac{2^2 + 0^2}{a^2} + \frac{0^2}{c^2} = \frac{4}{a^2}$$

จะได้

$$\begin{aligned} a &= 2 \times d_{200} \\ a &= 2 \times 2.0158 \text{ \AA} \\ a &= 4.0316 \text{ \AA} \end{aligned}$$

ที่พีค (002) มุม 2θ 43.5 องศา

$$\frac{1}{d_{002}^2} = \frac{0^2 + 0^2}{a^2} + \frac{2^2}{c^2} = \frac{4}{c^2}$$

จะได้

$$\begin{aligned} c &= 2 \times d_{002} \\ c &= 2 \times 2.0761 \text{ \AA} \\ c &= 4.1522 \text{ \AA} \end{aligned}$$

จากปริมาตร $V = a^3c$

$$V = (4.0316 \text{ \AA})^2 \times 4.1522 \text{ \AA}$$

$$V = 67.4890 (\text{ \AA})^3$$

ความหนาแน่นตามทฤษฎีใช้สมการ

$$\rho = \frac{M}{N_A \times V}$$

- เมื่อ ρ คือความหนาแน่น (g/cm^3)
 M คือน้ำหนักของสาร 1 โมล (g)
 N_A คือเลขอาโวกาโด
 V คือปริมาตร (cm^3)

ตัวอย่างการหาค่าความหนาแน่นของชิ้นงาน PMnN - PZT

$$\rho = \frac{M}{6.02 \times 67.4890 \times 10^{-1}}$$

$$\rho = \frac{326.3534}{40.6432}$$

$$\rho = 8.0297 \text{ g/cm}^3$$

ภาคผนวก ข
ปริมาณที่ใช้ในการคำนวณหาความหนาแน่น

% ZnO	อุณหภูมิ ซินเทอร์ °C	น้ำหนัก แห้ง (g)	น้ำหนัก เปียก (g)	น้ำหนัก ซั้ง ในน้ำ (g)	ความ หนาแน่น (g/cm ³)
0	900	0.7334	0.7843	0.6128	4.2764
	950	0.7456	0.7540	0.6477	6.8968
	1000	0.7410	0.7538	0.6569	7.1300
	1050	0.7400	0.7660	0.6680	7.5510
0.25	900	0.7015	0.7671	0.6409	5.5586
	950	0.6591	0.6463	0.5600	7.6373
	1000	0.8364	0.8373	0.7293	7.7440
	1050	0.8105	0.8183	0.7131	7.7043
0.5	900	0.6261	0.6603	0.5486	5.6052
	950	0.7569	0.7632	0.6650	7.7077
	1000	0.8275	0.8285	0.7220	7.7699
	1050	0.7718	0.7733	0.6730	7.6949
0.75	900	0.7019	0.7324	0.6129	5.8736
	950	0.8275	0.8280	0.7205	7.6976
	1000	0.7628	0.7640	0.6660	7.7836
	1050	0.7380	0.7382	0.6436	7.7521
1	900	0.7173	0.7345	0.6267	6.1413
	950	0.8361	0.8060	0.6985	7.7776
	1000	0.8512	0.8526	0.7439	7.8307
	1050	0.7881	0.7891	0.6877	7.7723

ภาคผนวก ก

Peak ID Report PMnN - PZT

	2-Theta	d (Å ⁰)	High	High %	d(Å ⁰)	I %	hkl	2-Theta	Delta
1	21.857	4.0629	187	7.9	4.0485	18.0	(100)	21.639	0.002
2	31.175	2.8666	871	36.6	2.8566	37.0	(110)	31.285	0.079
3	38.239	2.3517	363	15.3	2.3518	24.0	(111)	38.237	-0.002
4	43.592	2.0761	108	4.5	2.0745	10.0	(002)	43.557	-0.035
5	44.799	2.0518	134	5.6	2.0214	18.0	(200)	44.931	0.132
6	49.379	1.8440	96	4.0	1.8454	5.0	(102)	49.342	-0.041
7	50.137	1.8180	80	3.4	1.8171	9.0	(210)	50.163	0.026
8	50.278	1.8132	57	2.4	1.8119	4.0	(201)	50.318	0.039
9	54.841	1.6726	486	20.4	1.6000	40.0	(112)	54.690	-0.151
10	55.441	1.6560	297	12.5	1.6586	27.0	(211)	55.345	-0.096
11	64.380	1.4459	155	6.5	1.4445	7.0	(202)	64.451	0.071
12	64.601	1.4415	137	5.8	1.4406	10.0	(024)	64.648	0.047
13	64.720	1.4391	135	5.7	1.4386	10.0	(220)	64.749	-0.029
14	67.768	1.3816	21	0.9	1.3823	1.0	(003)	67.733	-0.035
15	69.021	1.3596	57	2.4	1.3597	2.0	(212)	69.017	-0.004
16	69.397	1.3531	17	0.7	1.3531	3.0	(300)	69.400	0.003

SCAN: 15.0/70.0/0.02/1(sec), CU, I(max)=2408, 11/25/04 13.40

PEAK; 35 – pts/Parabolic Filter, Threshold = 3.0, Cutoff = 0.1%, BG=3/1. ,Peak-Top=Summit

Note Intensity = Counts, 2T(0) = 0.0(deg), Wavelength to Computed d-Spacing = 1.54056 Å⁰

(CU/K-alpha)

PDF 50-0346 – Lead Titanium Zirconium Oxide <2T(0) = -0.16, d/d(0) = 1.0>

PDF 39-1007 – Lead Manganese NiObium Oxide <2T(0) = -0.24, d/d(0) = 1.0>

(Materials Data, Inc)

ภาคผนวก ง

PDF Card

PDF#60-0346: QM=Star(S); d=Diffraction; I=Diffraction											PDF Card		
Lead Titanium Zirconium Oxide											(rFeRrMIC)		
Pb (Zr _{0.44} Ti _{0.56}) O ₃													
Radiation=CuKα1				Lambda=1.54056				Filter=					
Calibration=				2θ=21.442-155.720				I/c(RIR)=					
Ref: Jin, Z., Testing & Analysis Centre, Suzhou Univ., P.R.China.													
ICDD Grant-In-Aid (1998)													
Tetragonal - (Unknown), P4mm (99)						Z=1		mp=					
CELL: 4.0172 x 4.0172 x 4.1391 <90.0 x 90.0 x 90.0>											P.S=tP5 (?)		
Density(c)=8.000		Density(m)=7.64A		Mwt=322.16		Vol=66.80		F(30)=92.3(0108,30/0)					
Ref: Ibid													
Color: Black													
Strong Lines: 2.88/4 2.84/4 2.34/2 1.65/2 4.02/2 2.01/2 4.14/2 1.67/1 2.07/1 1.44/1													
58 Lines, Wavelength to Compute Theta = 1.54056?(Cu), I%-Type = Peak Height													
#	d(?)	I(f)	(hkl)	2-Theta	Theta	1/(2d)	#	d(?)	I(f)	(hkl)	2-Theta	Theta	1/(2d)
1	4.1406	16.0	(0 0 1)	21.442	10.721	0.1208	30	1.0760	3.0	(3 2 1)	91.430	45.715	0.4647
2	4.0195	18.0	(1 0 0)	22.097	11.048	0.1244	31	1.0347	0.0	(0 0 4)	96.223	48.112	0.4832
3	2.8829	100.0	(1 0 1)	30.994	15.497	0.1734	32	1.0043	1.0	(4 0 0)	100.167	50.084	0.4979
4	2.8424	37.0	(1 1 0)	31.447	15.724	0.1759	33	1.0022	1.0	(1 0 4)	100.455	50.227	0.4989
5	2.3424	24.0	(1 1 1)	38.397	19.199	0.2135	34	0.9898	0.0	(2 2 3)	102.195	51.098	0.5052
6	2.0669	10.0	(0 0 2)	43.717	21.858	0.2417	35	0.9722	1.0	(1 1 4)	104.803	52.402	0.5143
7	2.0090	18.0	(2 0 0)	45.091	22.545	0.2489	36	0.9611	1.0	(3 0 3)	106.539	53.269	0.5202
8	1.8398	5.0	(1 0 2)	49.502	24.751	0.2718	37	0.9483	1.0	(4 1 1)	108.638	54.319	0.5273
9	1.8065	4.0	(2 0 1)	50.478	25.239	0.2768	38	0.9470	1.0	(3 3 0)	108.857	54.428	0.5280
10	1.7972	3.0	(2 1 0)	50.757	25.379	0.2782	39	0.9346	0.0	(3 1 3)	111.011	55.506	0.5350
11	1.6724	13.0	(1 1 2)	54.850	27.425	0.2990	40	0.9231	0.0	(3 3 1)	113.117	56.559	0.5417
12	1.6480	21.0	(2 1 1)	55.732	27.866	0.3034	41	0.9198	1.0	(2 0 4)	113.742	56.871	0.5436
13	1.4413	7.0	(2 0 2)	64.611	32.306	0.3469	42	0.9035	1.0	(4 0 2)	116.980	58.490	0.5534
14	1.4206	3.0	(2 2 0)	65.670	32.835	0.3520	43	0.8982	2.0	(4 2 0)	118.092	59.046	0.5567
15	1.3794	1.0	(0 0 3)	67.893	33.946	0.3625	44	0.8968	1.0	(2 1 4)	118.391	59.196	0.5575
16	1.3569	2.0	(2 1 2)	69.177	34.588	0.3685	45	0.8816	0.0	(4 1 2)	121.790	60.895	0.5672
17	1.3431	1.0	(2 2 1)	69.991	34.995	0.3723	46	0.8669	1.0	(3 2 3)	125.382	62.691	0.5768
18	1.3390	0.0	(3 0 0)	70.236	35.118	0.3734	47	0.8610	1.0	(3 3 2)	126.923	63.461	0.5807
19	1.3041	4.0	(1 0 3)	72.369	36.185	0.3832	48	0.8364	1.0	(2 2 4)	134.130	67.065	0.5978
20	1.2740	4.0	(3 0 1)	74.402	37.201	0.3925	49	0.8240	1.0	(4 2 2)	138.394	69.197	0.6068
21	1.2700	4.0	(3 1 0)	74.642	37.321	0.3935	50	0.8188	0.0	(3 0 4)	140.353	70.177	0.6106
22	1.2410	1.0	(1 1 3)	76.719	38.359	0.4028	51	0.8120	0.0	(4 0 3)	143.107	71.554	0.6158
23	1.2144	1.0	(3 1 1)	78.734	39.367	0.4117	52	0.8108	0.0	(1 0 5)	143.619	71.810	0.6167
24	1.1710	2.0	(2 2 2)	82.247	41.124	0.4269	53	0.8034	1.0	(4 3 0)	146.982	73.491	0.6224
25	1.1375	1.0	(2 0 3)	85.246	42.623	0.4396	54	0.8023	1.0	(3 1 4)	147.516	73.758	0.6232
26	1.1240	1.0	(3 0 2)	86.500	43.250	0.4448	55	0.7959	1.0	(4 1 3)	150.846	75.423	0.6282
27	1.1140	0.0	(3 2 0)	87.481	43.740	0.4488	56	0.7948	1.0	(1 1 5)	151.462	75.731	0.6291
28	1.0940	3.0	(2 1 3)	89.461	44.731	0.4568	57	0.7887	1.0	(5 0 1)	155.185	77.593	0.6340
29	1.0820	3.0	(3 1 2)	90.716	45.358	0.4619	58	0.7879	1.0	(5 1 0)	155.720	77.860	0.6346

PDF#39-1007: QM=Indexed(I); d=(Unknown); I=(Unknown)											PDF Card		
Lead Manganese Niobium Oxide													
Pb (Mn0.34 Nb0.66) O3													
Radiation=CuKa1				Lambda=1.5406				Filter=					
Calibration=				ZT=21.939-116.671				I/c(RIR)=					
Ref: Imoto, F., Takase, H., Kimura, N. Yogyo Kyokaishi (J. Ceram. Assoc. Jpn.), v94 p590 (1986)													
Cubic - (Unknown),						Z=							
CELL: 4.045 x 4.045 x 4.045 <90.0 x 90.0 x 90.0>													
Density(c)=8.410			Density(m)=7.45A			Mwt=335.20		Vol=66.18		F(14)=25.6(0.032,17.0)			
Ref: Ibid.													
Strong Lines: 2.86/X 2.02/5 4.05/4 1.65/3 2.33/2 0.91/2 1.43/1 1.28/1 1.81/1 1.08/1													
14 Lines, Wavelength to Compute Theta = 1.54056?(Cu), I%-Type = (Unknown)													
#	d(?)	I(f)	(hkl)	2-Theta	Theta	1/(2d)	#	d(?)	I(f)	(hkl)	2-Theta	Theta	1/(2d)
1	4.0480	37.0	(100)	21.939	10.970	0.1235	8	1.3490	3.0	(300)	69.640	34.820	0.3706
2	2.8600	100.0	(110)	31.249	15.624	0.1748	9	1.2790	10.0	(310)	74.063	37.031	0.3909
3	2.3340	19.0	(111)	38.541	19.270	0.2142	10	1.1680	5.0	(222)	82.521	41.261	0.4281
4	2.0230	45.0	(200)	44.762	22.381	0.2472	11	1.0820	8.0	(321)	90.780	45.390	0.4621
5	1.8090	9.0	(210)	50.403	25.202	0.2764	12	1.0110	4.0	(400)	99.264	49.632	0.4946
6	1.6510	27.0	(211)	55.585	27.793	0.3027	13	0.9535	6.0	(411)	107.772	53.886	0.5244
7	1.4310	11.0	(220)	65.133	32.567	0.3494	14	0.9050	17.0	(420)	116.671	58.336	0.5525

PDF#36-1482: QM=Star(S); d=Diffraction; I=Diffraction											PDF Card		
Lead Oxide											(cSCR)		
Pb O													
Radiation=CuKα1				Lambda=1.54056				Filter=Ni					
Calibration=				2θ=17.762-86.924				I/c(RIR)=					
Ref: Boher, P.													
Private Communication (1984)													
Orthorhombic - (Unknown), Cmma (67)						Z=4		mp=					
CELL: 5.6085 x 5.6036 x 4.9893 <90.0 x 90.0 x 90.0>											P.S.=cC8 (\$GA) (O Pb)		
Density(c)=9.455		Density(m)=10.02A		Mwt=223.20		Vol=156.80		F(30)=965.8(0010,300)					
Ref: Boher, P., Garnier													
C. R. Seances Acad. Sci., Ser. 2, v296 p203 (1984)													
NOTE: Preparation by thermal decomposition of lead dioxide \$GB-Pb O2 (Merck) at 793 K. Low temperature phase-transition. \$GA-PbO = \$GA-PbO orthorhombic at 200 K. See ICSD 62846, 62847, 62848, 62849 (PDF 78-1663, 64, 65, 78-1666).													
Color: Violet-red													
Strong Lines: 3.10/X 2.80/2 1.98/2 1.67/2 1.86/1 2.49/1 1.55/1 1.53/1 1.28/1 1.21/1													
42 Lines, Wavelength to Compute Theta = 1.540567(Cu), I%-Type = (Unknown)													
#	d(°)	I(f)	(hkl)	2-Theta	Theta	1/(2d)	#	d(°)	I(f)	(hkl)	2-Theta	Theta	1/(2d)
1	4.9893	3.0	(0 0 1)	17.762	8.881	0.1002	22	1.4021	2.0	(4 0 0)	66.648	33.324	0.3566
2	3.1037	100.0	(1 1 1)	28.740	14.370	0.1611	23	1.4009	2.0	(0 4 0)	66.713	33.356	0.3569
3	2.8042	16.0	(2 0 0)	31.887	15.943	0.1783	24	1.3498	0.0	(4 0 1)	69.593	34.796	0.3704
4	2.8018	16.0	(0 2 0)	31.915	15.957	0.1785	25	1.3487	0.0	(0 4 1)	69.658	34.829	0.3707
5	2.4946	11.0	(0 0 2)	35.971	17.986	0.2004	26	1.2773	6.0	(3 3 1)	74.178	37.089	0.3915
6	2.4446	0.0	(2 0 1)	36.733	18.367	0.2045	27	1.2740	0.0	(2 2 3)	74.402	37.201	0.3925
7	2.4430	0.0	(0 2 1)	36.758	18.379	0.2047	28	1.2539	3.0	(4 2 0)	75.803	37.902	0.3988
8	2.1113	1.0	(1 1 2)	42.795	21.398	0.2368	29	1.2532	3.0	(2 4 0)	75.853	37.927	0.3990
9	1.9820	16.0	(2 2 0)	45.740	22.870	0.2523	30	1.2473	1.0	(0 0 4)	76.276	38.138	0.4009
10	1.8639	13.0	(2 0 2)	48.820	24.410	0.2683	31	1.2223	2.0	(4 0 2)	78.128	39.064	0.4091
11	1.8632	13.0	(0 2 2)	48.839	24.420	0.2684	32	1.2215	2.0	(0 4 2)	78.189	39.095	0.4093
12	1.8420	0.0	(2 2 1)	49.439	24.719	0.2714	33	1.2160	0.0	(4 2 1)	78.611	39.305	0.4112
13	1.6710	16.0	(3 1 1)	54.899	27.450	0.2992	34	1.2155	0.0	(2 4 1)	78.649	39.325	0.4114
14	1.6699	16.0	(1 3 1)	54.939	27.469	0.2994	35	1.2131	5.0	(3 1 3)	78.835	39.418	0.4122
15	1.6631	0.0	(0 0 3)	55.182	27.591	0.3006	36	1.2127	5.0	(1 3 3)	78.866	39.433	0.4123
16	1.5515	11.0	(2 2 2)	59.521	29.761	0.3222	37	1.1898	0.0	(1 1 4)	80.692	40.346	0.4202
17	1.5335	11.0	(1 1 3)	60.300	30.150	0.3260	38	1.1677	0.0	(3 3 2)	82.547	41.274	0.4282
18	1.4454	0.0	(3 1 2)	64.406	32.203	0.3459	39	1.1397	2.0	(2 0 4)	85.042	42.521	0.4387
19	1.444	0.0	(1 3 2)	64.441	32.220	0.3461	40	1.1395	2.0	(0 2 4)	85.061	42.530	0.4388
20	1.4304	0.0	(2 0 3)	65.164	32.582	0.3496	41	1.1203	4.0	(4 2 2)	86.875	43.438	0.4463
21	1.430	0.0	(0 2 3)	65.179	32.590	0.3496	42	1.1198	4.0	(2 4 2)	86.924	43.462	0.4465

PDF#36-1100; QM=Star(S); d=Guinier; I=Densitometer											PDF Card		
Lead Niobium Oxide													
Pb14 Nb10 O39													
Radiation=CuKa1				Lambda=1.5406				Filter=					
Calibration=Internal(ThO2)				2T=5.431-90.015				I/c(RIR)=					
Ref: Scott, H.													
J. Solid State Chem., v43 p131 (1982)													
Orthorhombic - (Unknown), B						Z=		mp=					
CELL: 7.5218 x 7.5374 x 32.51 <90.0 x 90.0 x 90.0>						P.S.=cC0 (?)							
Density(c)=4.013		Density(m)=7.53A		Mwt=4453.84		Vol=1843.15		F(30)=24.1(.0122,102/0)					
Ref: Ibid.													
NOTE: The starting materials were Nb2 O5 (99.9%) and yellow Pb O (99.0%) which, after firing at 800 C to decompose some basic lead carbonate initially present, contained only the orthorhombic polymorph.													
Strong Lines: 3.09/X 1.61/3 2.66/3 1.90/2 1.23/1 1.63/1 2.71/1 1.88/1 1.54/1 1.33/1													
62 Lines, Wavelength to Compute Theta = 1.54056?(Cu), I%-Type = (Unknown)													
#	d(?)	I(f)	(h k l)	2-Theta	Theta	1/(2d)	#	d(?)	I(f)	(h k l)	2-Theta	Theta	1/(2d)
1	16.2600	0.0	(0 0 2)	5.431	2.715	0.0308	32	1.9623	0.0	(0 1 16)	46.225	23.113	0.2548
2	8.1300	0.0	(0 0 4)	10.873	5.437	0.0615	33	1.8988	24.0	(2 2 12)	47.866	23.933	0.2633
3	6.8380	2.0	(0 1 2)	12.936	6.468	0.0731	34	1.8848	9.0	(0 4 0)	48.244	24.122	0.2653
4	6.1790	4.0	(1 0 3)	14.322	7.161	0.0809	35	1.8803	9.0	(4 0 0)	48.367	24.183	0.2659
5	5.5300	0.0	(0 1 4)	16.014	8.007	0.0904	36	1.8229	0.0	(1 2 15)	49.992	24.996	0.2743
6	3.7630	0.0	(2 0 0)	23.624	11.812	0.1329	37	1.8134	0.0	(4 1 2)	50.272	25.136	0.2757
7	3.7630	0.0	(0 2 0)	23.624	11.812	0.1329	38	1.8076	0.0	(3 2 9)	50.445	25.222	0.2766
8	3.6690	0.0	(0 2 2)	24.238	12.119	0.1363	39	1.8026	0.0	(1 4 3)	50.595	25.297	0.2774
9	3.6690	0.0	(2 0 2)	24.238	12.119	0.1363	40	1.7808	0.0	(4 1 4)	51.259	25.629	0.2808
10	3.4200	0.0	(2 0 4)	26.033	13.016	0.1462	41	1.7579	0.0	(2 3 10)	51.976	25.988	0.2844
11	3.4200	0.0	(0 2 4)	26.033	13.016	0.1462	42	1.7397	0.0	(2 1 16)	52.561	26.280	0.2874
12	3.2960	0.0	(2 1 2)	27.030	13.515	0.1517	43	1.6285	11.0	(2 0 18)	56.458	28.229	0.3070
13	3.2590	0.0	(1 0 9)	27.343	13.671	0.1534	44	1.6285	11.0	(0 2 18)	56.458	28.229	0.3070
14	3.2190	2.0	(1 2 3)	27.689	13.845	0.1553	45	1.6088	33.0	(4 2 6)	57.213	28.607	0.3108
15	3.0910	100.0	(0 2 6)	28.860	14.430	0.1618	46	1.6088	33.0	(2 4 6)	57.213	28.607	0.3108
16	3.0910	100.0	(2 0 6)	28.860	14.430	0.1618	47	1.5469	5.0	(0 4 12)	59.729	29.865	0.3232
17	2.9840	0.0	(0 1 10)	29.919	14.960	0.1676	48	1.5448	6.0	(4 0 12)	59.818	29.909	0.3237
18	2.7042	10.0	(0 0 12)	33.036	16.518	0.1846	49	1.3548	2.0	(0 0 24)	69.299	34.650	0.3691
19	2.6611	30.0	(2 2 0)	33.638	16.819	0.1878	50	1.3312	6.0	(4 4 0)	70.709	35.355	0.3756
20	2.6210	0.0	(2 2 2)	34.088	17.044	0.1903	51	1.2316	13.0	(4 2 18)	77.428	38.714	0.4060
21	2.5940	0.0	(2 1 8)	34.562	17.281	0.1928	52	1.2316	13.0	(2 4 18)	77.428	38.714	0.4060
22	2.5310	4.0	(2 2 4)	35.437	17.718	0.1976	53	1.2240	4.0	(0 6 6)	77.999	39.000	0.4085
23	2.4833	0.0	(0 3 2)	36.141	18.070	0.2013	54	1.2213	5.0	(6 0 6)	78.204	39.102	0.4094
24	2.4645	3.0	(1 2 9)	36.426	18.213	0.2029	55	1.2074	6.0	(2 2 24)	79.281	39.640	0.4141
25	2.4436	2.0	(3 0 3)	36.764	18.382	0.2047	56	1.1947	6.0	(4 4 12)	80.294	40.147	0.4185
26	2.4011	1.0	(0 3 4)	37.423	18.711	0.2082	57	1.1916	5.0	(2 6 0)	80.545	40.273	0.4196
27	2.3387	2.0	(2 1 10)	38.460	19.230	0.2138	58	1.1895	6.0	(6 2 0)	80.717	40.358	0.4203
28	2.0837	0.0	(1 0 15)	43.412	21.706	0.2401	59	1.0995	5.0	(4 0 24)	88.946	44.473	0.4548
29	2.0731	0.0	(2 3 2)	43.624	21.812	0.2412	60	1.0995	5.0	(0 4 24)	88.946	44.473	0.4548
30	2.0540	2.0	(3 2 3)	44.141	22.070	0.2439	61	1.0908	6.0	(2 6 12)	89.847	44.923	0.4584
31	2.0239	0.0	(2 3 4)	44.741	22.370	0.2470	62	1.0892	6.0	(6 2 12)	90.015	45.007	0.4591

ประวัติผู้เขียนวิทยานิพนธ์

นายสุทัศน์ จันบัวลา เกิดเมื่อวันที่ 15 มีนาคม 2521 สำเร็จการศึกษาระดับมัธยมศึกษาตอนปลายที่ โรงเรียนโยธินบูรณะ ระดับปริญญาตรี หลักสูตรวิทยาศาสตร์บัณฑิต สาขาฟิสิกส์ มหาวิทยาลัยศรีนครินทรวิโรฒเมื่อปีการศึกษา 2543 เข้าศึกษาในหลักสูตรวิทยาศาสตรมหาบัณฑิตสาขาเทคโนโลยีเซรามิกในภาคปลายปีการศึกษา 2545 สำเร็จการศึกษในเดือนตุลาคม 2548 ปัจจุบันทำงานในตำแหน่งอาจารย์ประจำคณะวิทยาศาสตร์และเทคโนโลยี มหาวิทยาลัยราชภัฏสวนดุสิต

