Electronic Supplementary Information

Taguchi method assisted multiple effects optimization on optical and luminescence performance of Ce: YAG transparent ceramics for high power white LEDs

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1 Supporting table

Table S1. Orthogonal experiment plan and corresponding samples' label

No.	Factors			Corresponding Samples
	A	B	C	Label
1	1	1	1	A1B1C1
2	1	2	2	A1B2C2
3	1	3	3	A1B3C3
4	1	4	4	A1B4C4
5	2	1	2	A2B1C2
6	2	2	1	A2B2C1
7	2	3	4	A2B3C4
8	2	4	3	A2B4C3
9	3	1	3	A3B1C3
10	3	2	4	A3B2C4
11	3	3	1	A3B3C1
12	3	4	2	A3B4C2
13	4	1	4	A4B1C4
14	4	2	3	A4B2C3
15	4	3	2	A4B3C2
16	4	4	1	A4B4C1

Table S2. LE, CIE-CC and their SNR values of all Ce: YAG ceramics packed LED devices under COB power of 8.625 W

No.	Sample label	LE, lm/W	CIE-CC	Distance to ideal CIE (0.33, 0.33)	SNR/ dB (LE)	SNR/ dB (Ideal CIE)
1	A1B1C1	16.92	(0.2129, 0.1623)	0.2088	24.568	13.605
2	A1B2C2	23.34	(0.2713, 0.2777)	0.0830	27.362	21.612
3	A1B3C3	19.96	(0.3409, 0.4042)	0.0714	26.603	22.924
4	A1B4C4	37.64	(0.3980, 0.4867)	0.1667	31.513	15.560
5	A2B1C2	12.78	(0.2064, 0.1476)	0.2245	22.131	12.976
6	A2B2C1	29.7	(0.3487, 0.4311)	0.0990	29.455	20.088
7	A2B3C4	37.17	(0.3798, 0.4762)	0.1507	31.403	16.440
8	A2B4C3	26.09	(0.4120, 0.5282)	0.2102	28.329	13.546
9	A3B1C3	13.11	(0.2090, 0.1535)	0.2184	22.352	13.215
10	A3B2C4	32.17	(0.3032, 0.3370)	0.0302	30.149	30.410
11	A3B3C1	27.76	(0.4178, 0.5431)	0.2261	28.868	12.916
12	A3B4C2	29.54	(0.4261, 0.5474)	0.2335	29.408	12.636
13	A4B1C4	23.74	(0.2293, 0.1944)	0.1735	27.509	15.214
14	A4B2C3	23.77	(03683, 0.4665)	0.1375	27.521	17.235
15	A4B3C2	30.48	(0.4211, 0.5475)	0.2315	29.680	12.708
16	A4B4C1	32.31	(0.4307, 0.5486)	0.2364	30.187	12.526

Table S3. LE, CIE-CC and their SNR values of all Ce: YAG ceramics packed LED devices under COB power of 27.69 W

No.	Sample label	LE, lm/W	CIE-CC	Distance to ideal CIE (0.33, 0.33)	SNR/ dB (LE)	SNR/ dB (Ideal CIE)
1	A1B1C1	22.10	(0.1988, 0.1511)	0.2265	26.888	12.899
2	A1B2C2	29.98	(0.2399, 02281)	0.1407	29.537	17.033
3	A1B3C3	27.05	(0.2934, 0.3215)	0.0412	28.643	27.696
4	A1B4C4	51.67	(0.3594, 0.4116)	0.0825	34.265	21.675
5	A2B1C2	17.63	(0.1920, 0.1373)	0.2417	24.925	12.336
6	A2B2C1	40.45	(0.3197, 0.3796)	0.0480	32.138	26.383
7	A2B3C4	51.37	(0.3520, 0.4236)	0.0922	34.214	20.706
8	A2B4C3	35.71	(0.3597, 0.4240)	0.0943	31.056	20.506
9	A3B1C3	18.88	(0.1986, 0.1511)	0.2265	25.52	12.899
10	A3B2C4	45.72	(0.2848, 0.3114)	0.0539	33.202	25.376
11	A3B3C1	37.05	(0.3626, 0.4342)	0.1053	31.376	19.547
12	A3B4C2	40.35	(0.3880, 0.4685)	0.1459	32.117	16.716
13	A4B1C4	35.14	(0.2261, 0.2046)	0.1676	30.916	15.513
14	A4B2C3	33.82	(0.3364, 0.4112)	0.0782	30.583	22.140
15	A4B3C2	41.96	(0.3768, 0.4619)	0.1356	32.457	17.352
16	A4B4C1	44.83	(0.3914, 0.4747)	0.1530	33.031	16.308

Table S4. SNR responses of LE and CIE-CC of the as-constructed LED devices under P=8.625 W from the Taguchi method

Levels	SNR (LE/ CIE-CC)		
	A: Thickness	B: Doping concentration	C: Surface roughness
1	27.362/18.425	24.140/13.752	28.270/14.784
2	27.829/15.763	28.622/22.336	27.145/14.983
3	27.694/17.294	28.986/16.247	26.051/16.730
4	28.724/14.421	29.859/13.484	30.144/19.406

Table S5. SNR responses of LE and CIE-CC of the as-constructed LED devices under P=27.69 W from the Taguchi method

Levels	SNR (LE/ CIE-CC)		
	A: Thickness	B: Doping concentration	C: Surface roughness
1	29.833/19.982	27.062/13.412	30.858/18.784
2	30.583/19.826	31.365/22.731	29.759/15.859
3	30.553/18.635	31.673/21.325	28.951/20.810
4	31.747/17.826	32.617/18.801	33.149/20.818

Table S6. ANOVA results for LE and CIE-CC of various as-constructed devices under 8.625 W

	Source of variation	Sum of square	d.f.	Mean squares	F value	P value
LE	X1	20.594	3	6.865	1.3	0.3575
	X2	505.555	3	168.518	31.93	0.0004
	X3	306.715	3	102.238	19.37	0.0017
	Error	31.667	6	5.278		
	Total	864.531	15			
CIE-CC	X1	0.00826	3	0.00275	1.95	0.2223
	X2	0.03948	3	0.01316	9.34	0.0112
	X3	0.01092	3	0.00364	2.58	0.1487
	Error	0.00845	6	0.00141		
	Total	0.06711	15			

Table S7. ANOVA results for LE and CIE-CC of various as-constructed devices under 27.69 W

	Source of variation	Sum of square	d.f.	Mean squares	F value	P value
LE	X1	79.08	3	26.361	2.82	0.1294
	X2	888.86	3	296.286	31.7	0.0004
	X3	650.92	3	216.972	23.21	0.0011
	Error	56.08	6	9.346		
	Total	1674.93	15			
CIE-CC	X1	0.00064	3	0.00021	0.22	0.8825
	X2	0.04487	3	0.01496	15.1	0.0033
	X3	0.0105	3	0.0035	3.53	0.088
	Error	0.00594	6	0.00099		
	Total	0.06196	15			

2 MATLAB® ANOVA analysis source program under different powder

(1) ANOVA for LE under 3.125 W

```
>> y=[23.61 31.85 26.65 48.23 17.61 40.15 48.87 35.81 15.91 43.87 43.53 42.26 32.91 31.48 40.05 42.37]';
>> g1=[0.4 0.4 0.4 0.4 0.8 0.8 0.8 0.8 1.0 1.0 1.0 1.0 1.5 1.5 1.5 1.5];
>>g2={'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'0.2%'};
>>g3={'W40';'W20';'W10';'W0.6';'W20';'W40';'W0.6';'W10';'W10';'W0.6';'W40';'W20';'W0.6';'W10';'W20';'W40'};
>> p=anovan(y,{g1,g2,g3})
```

ANOVA for CIE-CC under 3.125 W

```
>> y=[0.191 0.07 0.107 0.164 0.213 0.126 0.143 0.220 0.220 0.212 0.225 0.236 0.165 0.155 0.234 0.372]';
>> g1=[0.4 0.4 0.4 0.4 0.8 0.8 0.8 0.8 1.0 1.0 1.0 1.0 1.5 1.5 1.5 1.5];
>>g2={'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'0.2%'};
>>g3={'W40';'W20';'W10';'W0.6';'W20';'W40';'W0.6';'W10';'W10';'W0.6';'W40';'W20';'W0.6';'W10';'W20';'W40'};
>> p=anovan(y,{g1,g2,g3})
```

(2) ANOVA for LE under 8.625 W

```
>> y=[16.92 23.34 19.96 37.64 12.78 29.7 37.17 26.09 13.11 32.17 27.76 29.54 23.74
23.77 30.48 32.31]';
>> g1=[0.4 0.4 0.4 0.4 0.8 0.8 0.8 0.8 1.0 1.0 1.0 1.0 1.5 1.5 1.5 1.5];
>>g2={'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'
0.2%';'0.01%';'0.05%';'0.1%';'0.2%'};
>>g3={'W40';'W20';'W10';'W0.6';'W20';'W40';'W0.6';'W10';'W10';'W0.6';'W40';'W20';'W0.6';'
W10';'W20';'W40'};
>> p=anovan(y,{g1,g2,g3})
```

ANOVA for CIE-CC under 8.625 W

```
>> y=[0.2088 0.0830 0.0714 0.1667 0.2245 0.0990 0.1507 0.2102 0.2184 0.0302 0.2261
0.2335 0.1735 0.1375 0.2315 0.2364]';
>> g1=[0.4 0.4 0.4 0.4 0.8 0.8 0.8 0.8 1.0 1.0 1.0 1.0 1.5 1.5 1.5 1.5];
>>g2={'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'
0.2%';'0.01%';'0.05%';'0.1%';'0.2%'};
>>g3={'W40';'W20';'W10';'W0.6';'W20';'W40';'W0.6';'W10';'W10';'W0.6';'W40';'W20';'W0.6';'
W10';'W20';'W40'};
>> p=anovan(y,{g1,g2,g3})
```

(3) ANOVA for LE under 27.69 W

```
>> y=[22.10 29.98 27.05 51.67 17.63 40.45 51.37 35.71 18.88 45.72 37.05 40.35 35.14
33.82 41.96 44.83]';
>> g1=[0.4 0.4 0.4 0.4 0.8 0.8 0.8 0.8 1.0 1.0 1.0 1.0 1.5 1.5 1.5 1.5];
>>g2={'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'
0.2%';'0.01%';'0.05%';'0.1%';'0.2%'};
>>g3={'W40';'W20';'W10';'W0.6';'W20';'W40';'W0.6';'W10';'W10';'W0.6';'W40';'W20';'W0.6';'
W10';'W20';'W40'};
>> p=anovan(y,{g1,g2,g3})
```

ANOVA for CIE-CC under 27.69 W

```
>> y=[0.2265 0.1407 0.0412 0.0825 0.2417 0.0480 0.0922 0.0943 0.2265 0.0539 0.1053
0.1459 0.1676 0.0782 0.1356 0.1530]';
>> g1=[0.4 0.4 0.4 0.4 0.8 0.8 0.8 0.8 1.0 1.0 1.0 1.0 1.5 1.5 1.5 1.5];
>>g2={'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'0.2%';'0.01%';'0.05%';'0.1%';'
0.2%';'0.01%';'0.05%';'0.1%';'0.2%'};
>>g3={'W40';'W20';'W10';'W0.6';'W20';'W40';'W0.6';'W10';'W10';'W0.6';'W40';'W20';'W0.6';'
W10';'W20';'W40'};
>> p=anovan(y,{g1,g2,g3})
```