

Supporting Information

Rare Earth-Free GaZnON Phosphor Prepared by Combustion for White Light-Emitting Diodes

Neelu Chouhan,^{[a][b]#} Chun Che Lin,^{[a]#} Shu-Fen Hu,^{*[c]} and Ru-Shi Liu^{*[a][d]}

[#]These authors contributed equally

^aDepartment of Chemistry, National Taiwan University
No. 1, Sec. 4, Roosevelt Road, Taipei, 10617 Taiwan (R.O.C)
E-mail: rslu@ntu.edu.tw

^bDepartment of Pure and Applied Chemistry, University of Kota, Kota, Rajasthan-324005 India

^cDepartment of Physics, National Taiwan Normal University No. 88, Sec.4, Ting-Chou Rd., Taipei
116 Taiwan (R.O.C) E-mail: sfhu.hu@gmail.com

^dDepartment of Mechanical Engineering and Graduate Institute of Manufacturing Technology,
National Taipei University of Technology No. 1, Sec. 3, Zhongxiao E. Rd., Taipei, 10608 Taiwan
(R.O.C.)

Table S1. Analytical EDX corresponding to HRTEM and UV/DRS studies results of GaZnON, synthesised at 300°C temperature and different time interval (1-7 h).

Sample	% Zn	% Ga	Ga/Zn	Band Gap
U-1 h	58.39	41.60	0.71	3.53 eV
U-2 h	40.25	59.74	1.48	3.48 eV
U-3 h	44.47	55.53	1.24	3.22 eV
U-4 h	46.62	53.37	1.14	3.21 eV
U-5 h	46.70	53.30	1.14	3.21 eV
U-6 h	46.34	53.65	1.15	3.23 eV
U-7 h	47.84	52.16	1.09	3.20 eV
Ga₂O₃	-	100%	-	4.40 eV

Table S2. Elemental composition of GaZnON synthesised at different temperatures (200-900°C) and 1h heating, observed by HRTEM corresponding EDX.

Sample	Zn	Ga	Ga/Zn
200°C	49.4(6)	50.5(4)	1.0(2)
300°C	48.6(3)	51.3(7)	1.0(5)
400°C	41.6(6)	58.3(4)	1.4(1)
500°C	42.5(1)	57.4(9)	1.3(5)
550°C	44.8(5)	55.1(5)	1.2(2)
700°C	47.2(4)	52.7(6)	1.1(1)
900°C	48.3(4)	51.7(6)	1.0(1)

Table S3. Lattice fringes separated by a distance of 0.61 nm are also observed in the HRTEM image (Fig. 2b), which indicates that the crystal growth direction was along the reflection plane (011) and (002).

Readings	Lattice distance (nm)
Distance 1	0.67
Distance 2	0.65
Distance 3	0.60
Distance 4	0.60
Distance 5	0.60
Distance 6	0.61
Distance 7	0.57
Distance 8	0.64
Distance 9	0.60
Distance 10	0.60
Distance 11	0.64
Distance 12	0.61
Distance 13	0.57
Distance 14	0.64
Distance 15	0.58
Average distance	0.61

Table S4. CIE parameters for GaZnON calculated using CIE 3.1 software.

Heating time	Mode	Ex/ eV	Peak em /ex	x	y	T / K	dc	FWHM /cm
1 h	Em/ex	300	380/348	0.1491	0.1011	34367	-	6.3
2 h	Em/ex	300	391/353	0.3359	0.2201	4360	8.5e-02	8.3
3 h	Em/ex	300	400/336	0.3750	0.2478	2572	7.1e-02	6.6
4 h	Em/ex	300	400/335	0.3640	0.2479	2884	6.9e-02	5.9
5 h	Em/ex	300	403/329	0.1814	0.2074	34463	4.3e-02	4.5
6 h	Em/ex	300	397/336	0.1798	0.2003	34463	4.5e-02	5.6
7 h	Em/ex	300	404/336	0.1828	0.2173	34463	4.2e-02	5.0

Table S5. Package data.

Phosphor synthesis temp. (°C)	chip wavelength	phosphor weight	I _v (mcd)	CIE-x	CIE-y	I _v (lm)	W (mW)	V _f (V)
200	386 nm	40%	9.94	0.217	0.190	0.021	0.88	3.28
300	394 nm	60%	8.54	0.212	0.205	0.024	0.54	3.28
400	402 nm	60%	21.52	0.182	0.115	0.059	1.91	3.34
500	410-415 nm	60%	18.26	0.176	0.069	0.052	1.79	3.47
Pristine Ga ₂ O ₃	426 nm	60%	44.57	0.171	0.036	0.123	3.36	3.17

Table S6. Quantum efficiency of GaZnON phosphors with different reaction temperature.

Reaction Temperature	Internal QE	Absorption	External QE
200°C	37.5	77.6	29.1
300°C	45.4	80.7	36.6
400°C	40.8	75.9	31.0
500°C	10.3	66.3	6.8

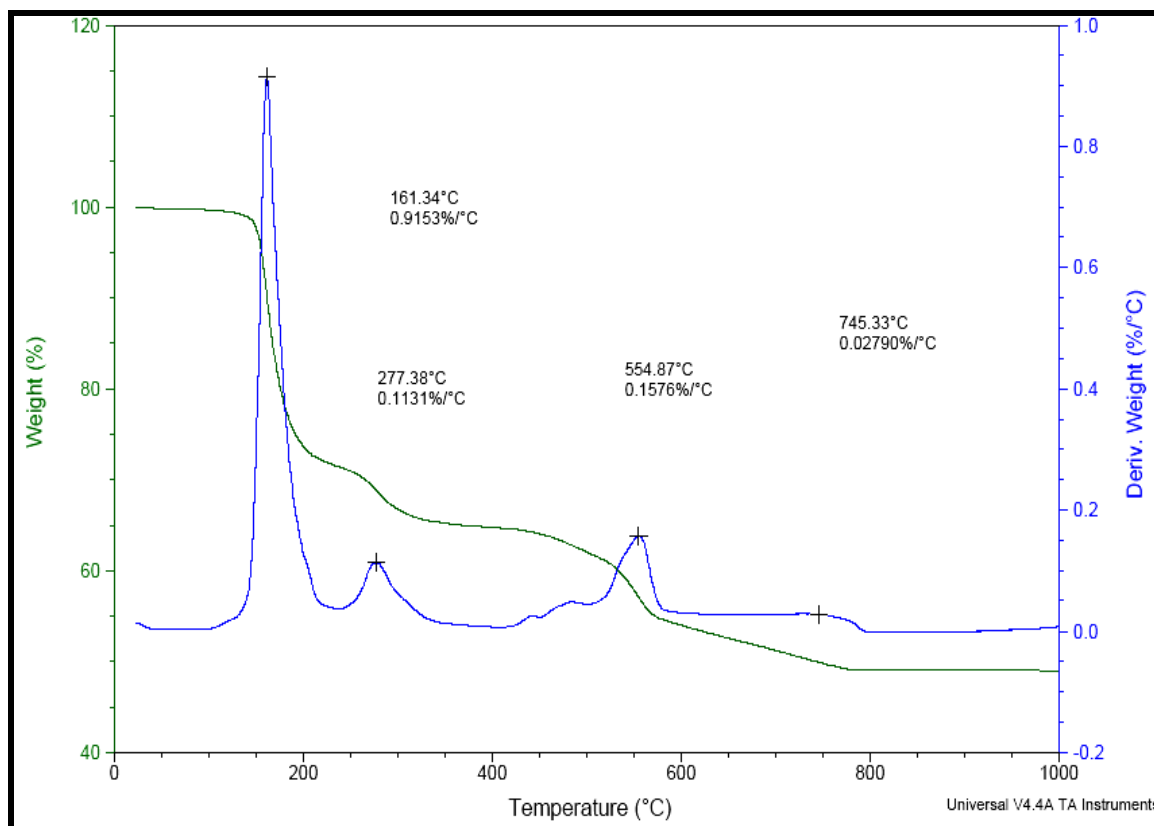


Figure S1. Thermo gravimetric analysis and differential scanning calorimetric plots for thermal decomposition of urea at the temperature range 0-1000°C.