Electronic Supplementary Material (ESI) for CrystEngComm.

Supporting Information

Synthesis and characteristics of $ZnGa_2O_4$ hollow nanostructures via carbon@$Ga(OH)CO_3$@$Zn(OH)_2$ by hydrothermal method

Bong Kyun Kang, [a] *Hyeong Dae Lim,* [a] *Sung Ryul Mang,* [b] *Keun Man Song,* [a] *Mong Kwon Jung,* [c] *and Dae Ho Yoon*[a,b*]

[a] School of Advanced Materials Science and Engineering, Sungkyunkwan University, Suwon 440-746, Republic of Korea,

[b] SKKU Advanced Institute of Nanotechnology (SAINT), Sungkyunkwan University, Suwon 440-746, Republic of Korea,

[c] Hyosung Corporation, R&D Business Labs, Anyang, 431-080, Republic of Korea.

E-mail: dhyoon@skku.edu (D. H. Yoon)

Sample	Carbon	Concentration of $Ga(NO_3)_3 \cdot xH_2O$	Urea	Concentration of $(C_4H_6O_4)Zn*2H_2O$	Sovent(water)
Sample 1	150 mg	3 mmol	30 mmol	2 mmol	50 mL
Sample 2	150 mg	3 mmol	30 mmol	2.5 mmol	50 mL
Sample 3	150 mg	3 mmol	30 mmol	3 mmol	50 mL
Sample 4	150 mg	3 mmol	30 mmol	3.5 mmol	50 mL

Table S1 Concentration of starting materials for carbon@$Ga(OH)CO_3$@$Zn(OH)_2$ core-shell-shell NSs.

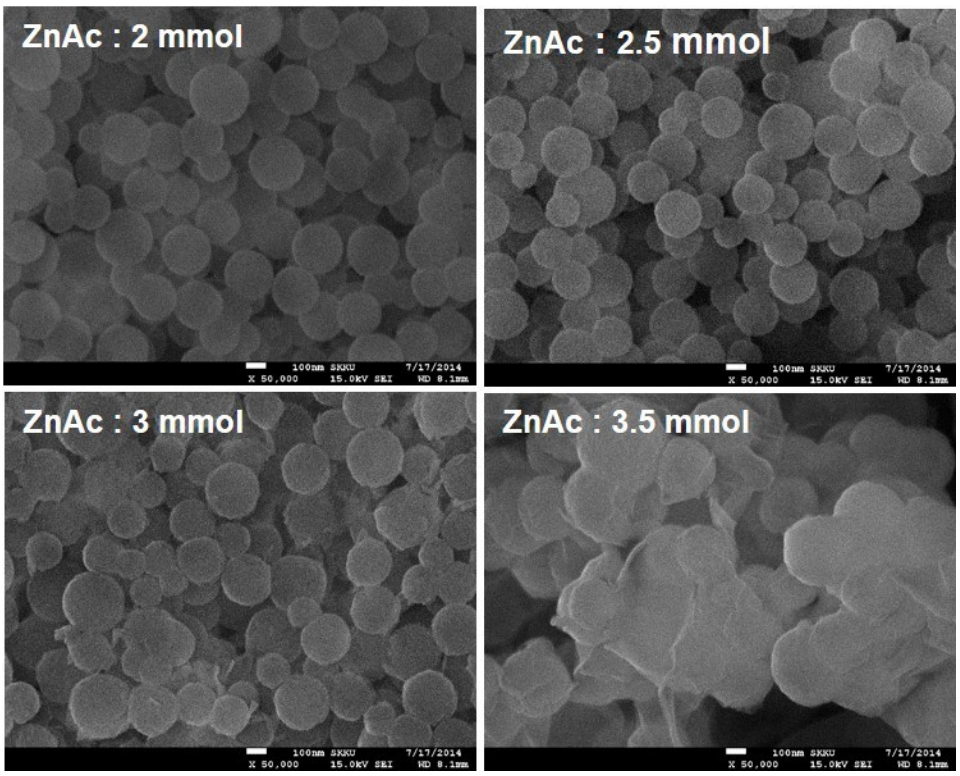

Fig. S1 FESEM images of the carbon@Ga(OH)CO_3@$Zn(OH)_2$ core-shell-shell NSs before calcination : concentration of ZnAc: 2, 2.5, 3 and 3.5 mmol.

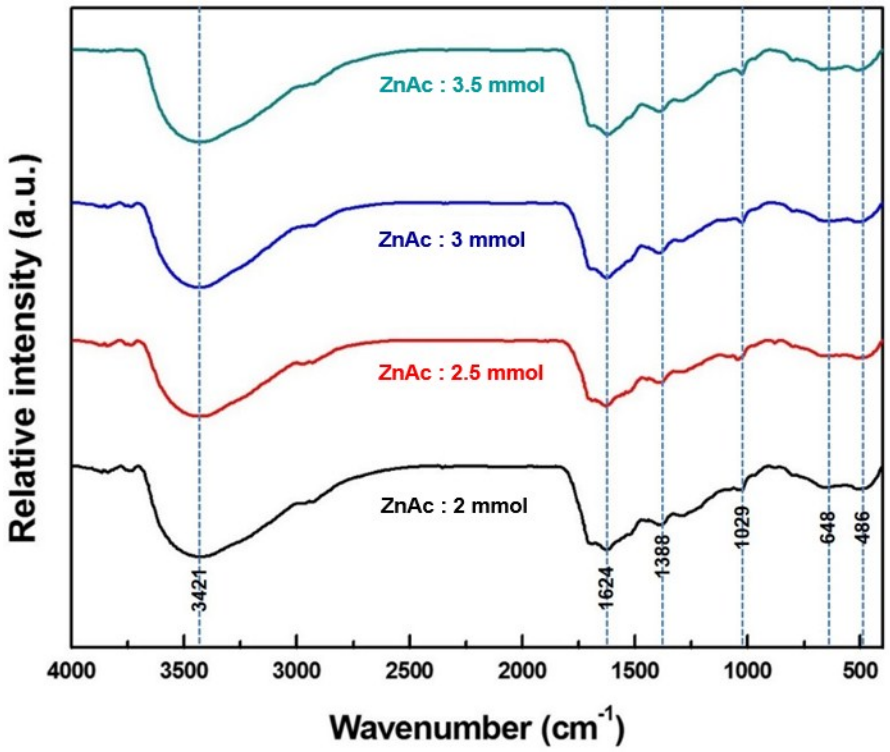

Fig. S2 FTIR spectra of the carbon@Ga(OH)CO_3@$Zn(OH)_2$ core-shell-shell NSs before calcination : concentration of ZnAc: 2, 2.5, 3 and 3.5 mmol.

Fig. S2 shows the FTIR spectra in the 4000 ~ 400 cm^{-1} region of the carbon@Ga(OH)CO_3@$Zn(OH)_2$ core-shell-shell NSs before calcination as a function of ZnAc. The vibration modes at 1600 and 1750 cm^{-1} are attributed to the C=O and C=C vibrations by the aromatization of glucose during hydrothermal treatment. The band absorption of carbon@Ga(OH)CO_3@$Zn(OH)_2$ core-shell-shell NSs was observed at 1388 cm^{-1} due to the ν_3 mode of interlamellar $[CO_3]^{2-}$ ions according to previous reports.[1] Broad absorption peaks positioned at 486 ~ 648 cm^{-1} (Ga-OH and Zn-OH stretching vibration) are identified in the carbon@Ga(OH)CO_3@$Zn(OH)_2$ core-shell-shell NSs before calcination.[2-3]

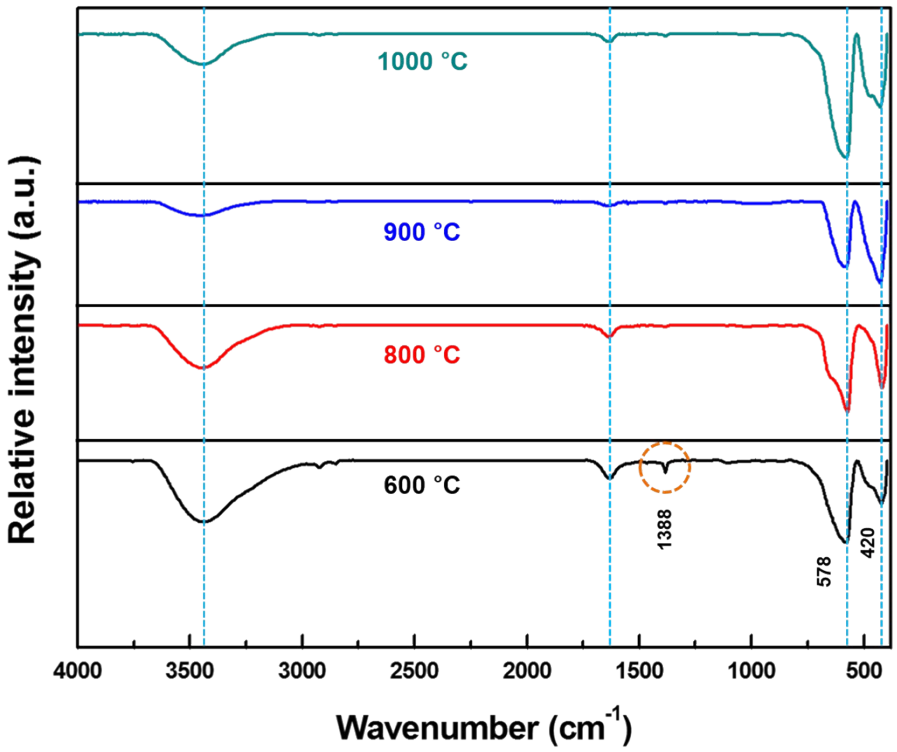

Fig. S3 FTIR spectra of the $ZnGa_2O_4$ (ZnAc : 2.5 mmol) hollow NSs after calcination from 600 to 1000 ºC for 1 hour in air atmosphere.

The band absorption of $ZnGa_2O_4$ hollow NSs at 600 ºC for 1 hour was observed at 1388 cm^{-1}. It indicated that the component of the shell are consist of residual interlamellar $[CO_3]^{2-}$ anions in $Ga(OH)CO_3$ shell. Strong absorption peaks positioned at 420 and 578 cm^{-1} (Ga-O and Zn-O stretching vibration) in Fig. S3 are identified in the $ZnGa_2O_4$ hollow NSs.[4] Furthermore, the FTIR spectra show a broad absorption band of the -OH group (1631, 3436 cm^{-1}), which results from the H_2O absorbed by the $ZnGa_2O_4$ hollow NSs when the samples were analyzed at room temperature in the air.

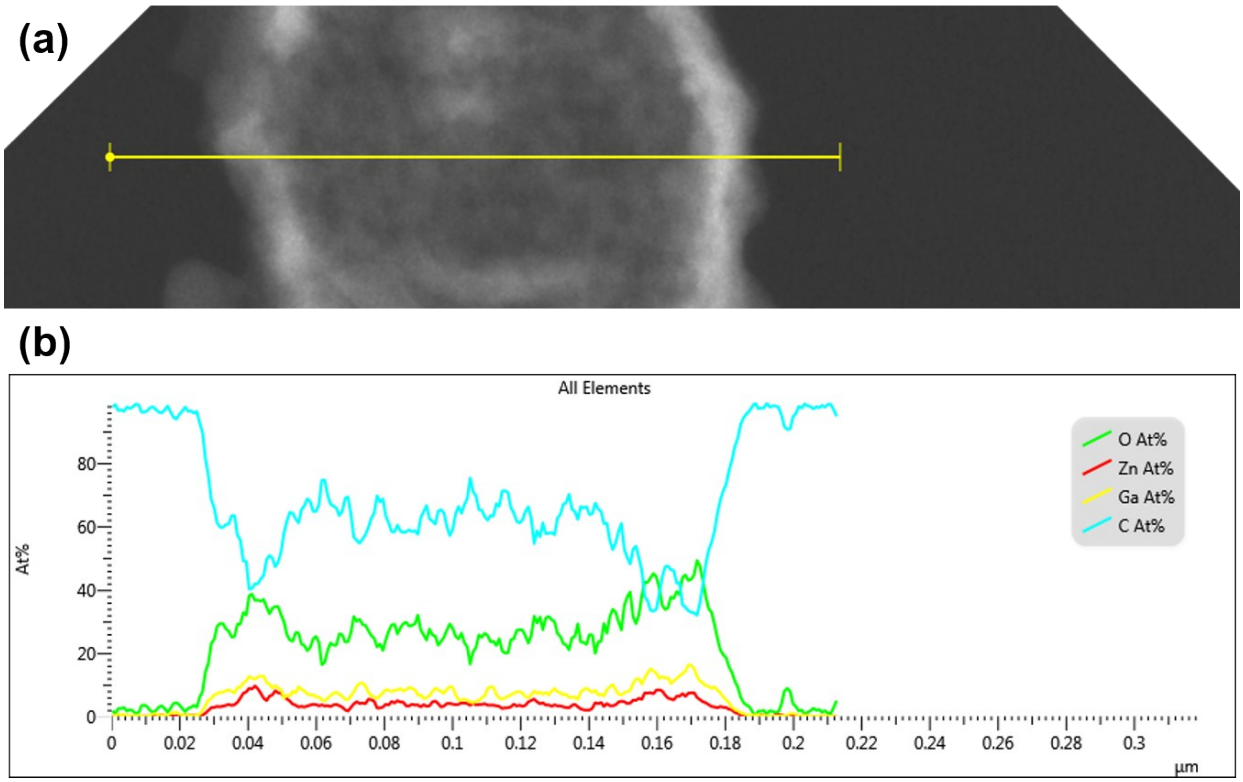

Fig. S4 The STEM (a) image and the EDS (b) line scan of $ZnGa_2O_4$ (ZnAc : 2.5 mmol) hollow NSs. EDS line scan taken along the indicated lines shown in the STEM image.

The formation of $ZnGa_2O_4$ hollow NSs was verified again by scanning TEM (STEM) image and the elemental line scanning profile in Fig. S4 (a) and (b). The presence of Ga and Zn in the same edge region can be attributed to the formation of $ZnGa_2O_4$ shell.

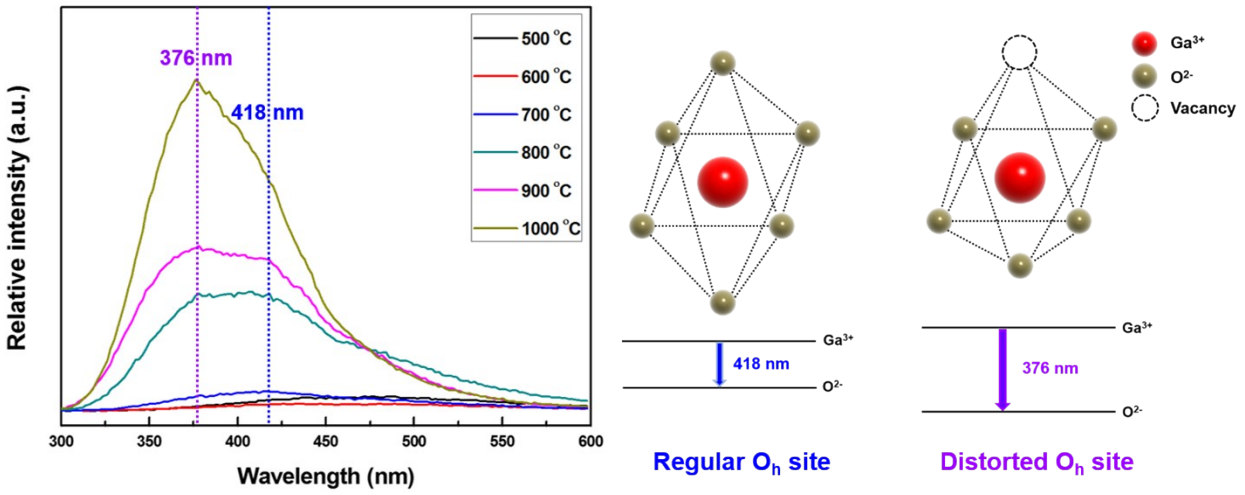

Fig. S5 CL (a) spectra and representative band-structure scheme (b) for the UV and blue luminescence in $ZnGa_2O_4$ (ZnAc : 2.5 mmol) hollow nanostructures.

References

1 L. S. Esteban, G. S. Mayela, R. G. Ma. Luisa, S. Isaac, *J. Porous Mat.*, 1996, **3**, 169.

2 H. D. Lutz, C. Jung, R. Mörtel, H. Jacobs, R. Stahl, *Spectrochim. Acta A*, 1998, **54**, 893.

3 V. A. Macrae, A. J. Downs, *Phys . Chem. Chem. Phys.*, 2004, **6**, 4571.

4 M. Yu, J. Lin, Y. H. Zhou, S. B. Wang, *Mater. Lett.*, 2002, **56**, 1007.