**Electronic Supplementary Information**

# Morphological evolution of monodispersed ZnO nanorods to 3 dimensional hierarchical flowers by hydrothermal growth

**M. Navaneethan*[a], J. Archana[b], Y. Hayakawa[a, b]**

[1]Research Institute of Electronics, Shizuoka University

[2]Graduate School of Science and Technology, Shizuoka University

3-5-1 Johoku, Naka-Ku, Hamamatsu, Shizuoka 432-8011, Japan.

## 1.1. Characterization techniques

XRD patterns were recorded using Rigaku (Japan) X–ray diffractometer (RINT–2200) with CuKα radiation at a 0.02˚/sec step interval. PL spectrum was obtained using He – Cd laser source of 325 nm excitation wavelength. FESEM images were recorded using JEOL JSM 6320F field emission scanning electron microscope. TEM images were recorded by JEOL JEM 2100F transmission electron microscope at an accelerating voltage of 200 kV. Carbon coated Cu grid was used to acquire the TEM images. A drop of solution containing ZnO nanostructures in ethanol was casted on Cu grid and it was dried.

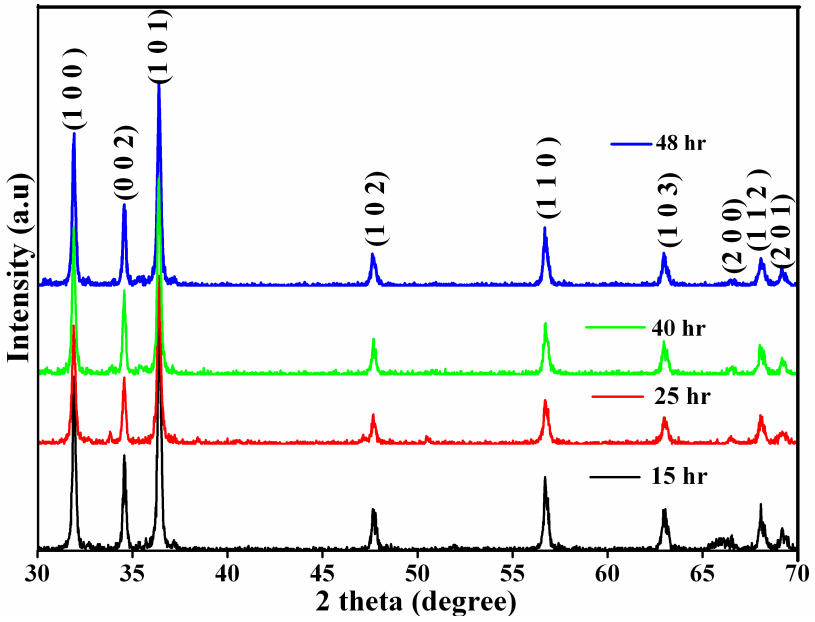


**Fig. 1. XRD patterns of ZnO nanostrcutres on FTO substrates for various growth periods.**

Fig. 1 shows XRD patterns of ZnO nanostructures grown at various growth periods such as 15, 25, 40 and 48 hr. All the diffraction peaks were indexed to wurtzite crystal structure and well matched to the standard JCPDS Card no. 89-0510[1]. No other peaks related to impurity or unreactant were detected. The sharp and strong peaks indicated the well crystalline nature of the ZnO nanostructures. XRD patterns of the samples exhibited the similar peak position and relatively similar intensity. As we have seen from the FESEM image of 15 hr and 25 hr, the morphology of the sample is nanorod. In 25 hr growth, a self-assembly of nanorods resulted the formation of ball-like structure. In addition to that, the sheet-like formation was observed in the 40 hr and 48 hr from the randomly attachment of the ZnO nanorods. Therefore, the XRD patterns of the samples are same. Also, the wurtzite phase is more stable for ZnO. Due to the self-assembly of the ZnO nanorods, the crystal structure does not affected much as seen in the XRD patterns.

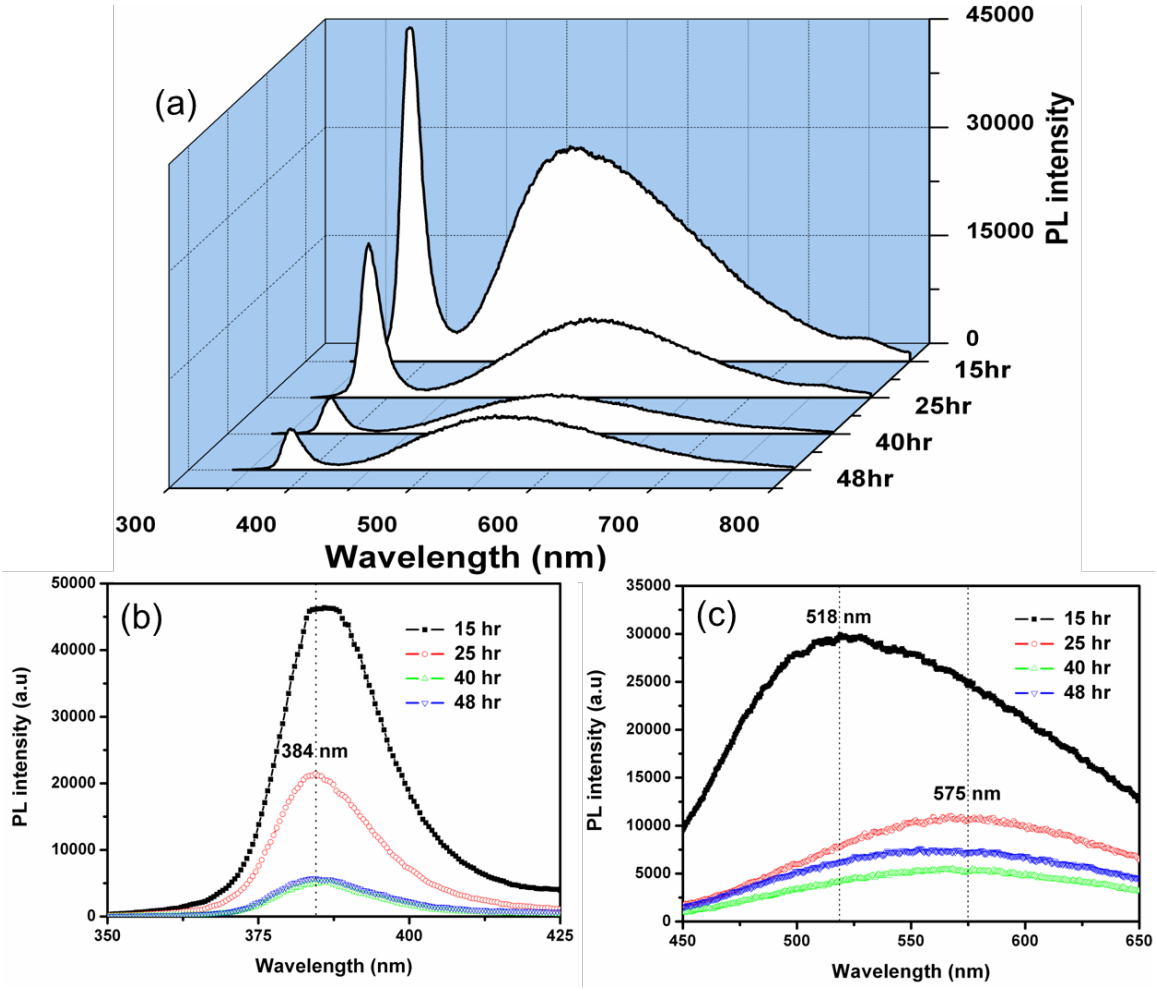


**Fig. 2 (a) Photoluminescence, (b) Expanded near band edge emission, and (c) expanded trap level emission spectra of ZnO nanostructures at various growth periods.**

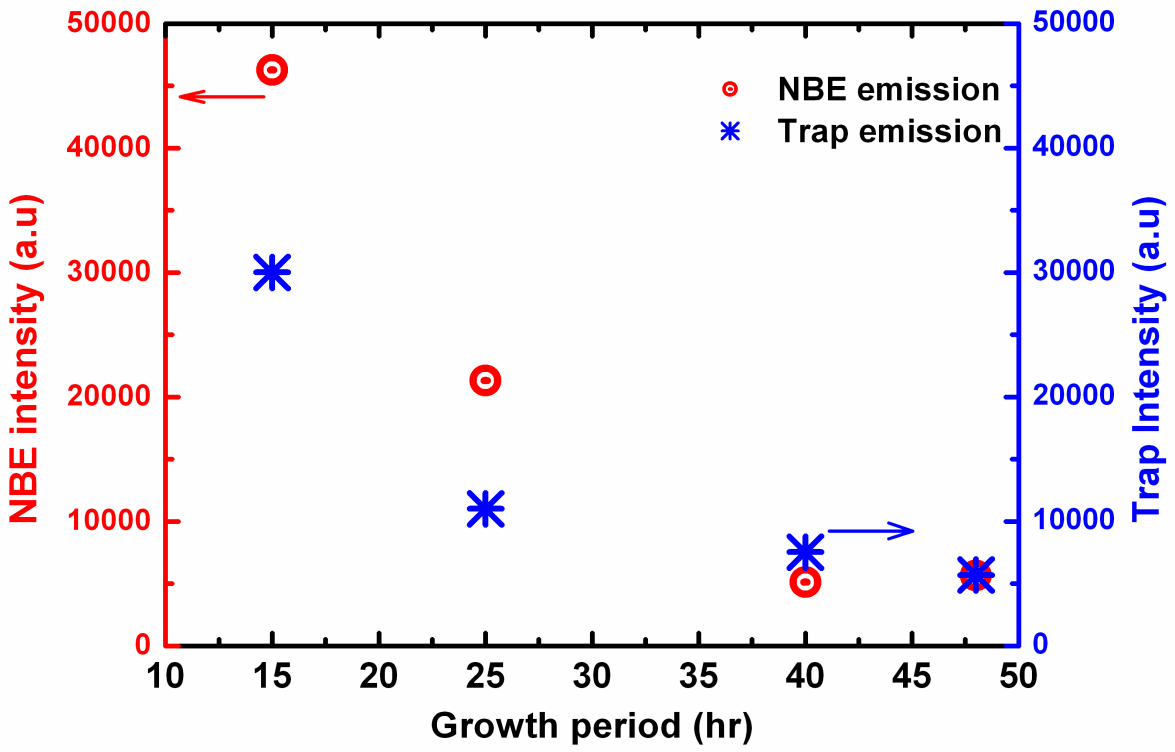


**Fig. 3. Relationship between the NBE emission and trap level emissions of ZnO nanostructures at various growth periods**

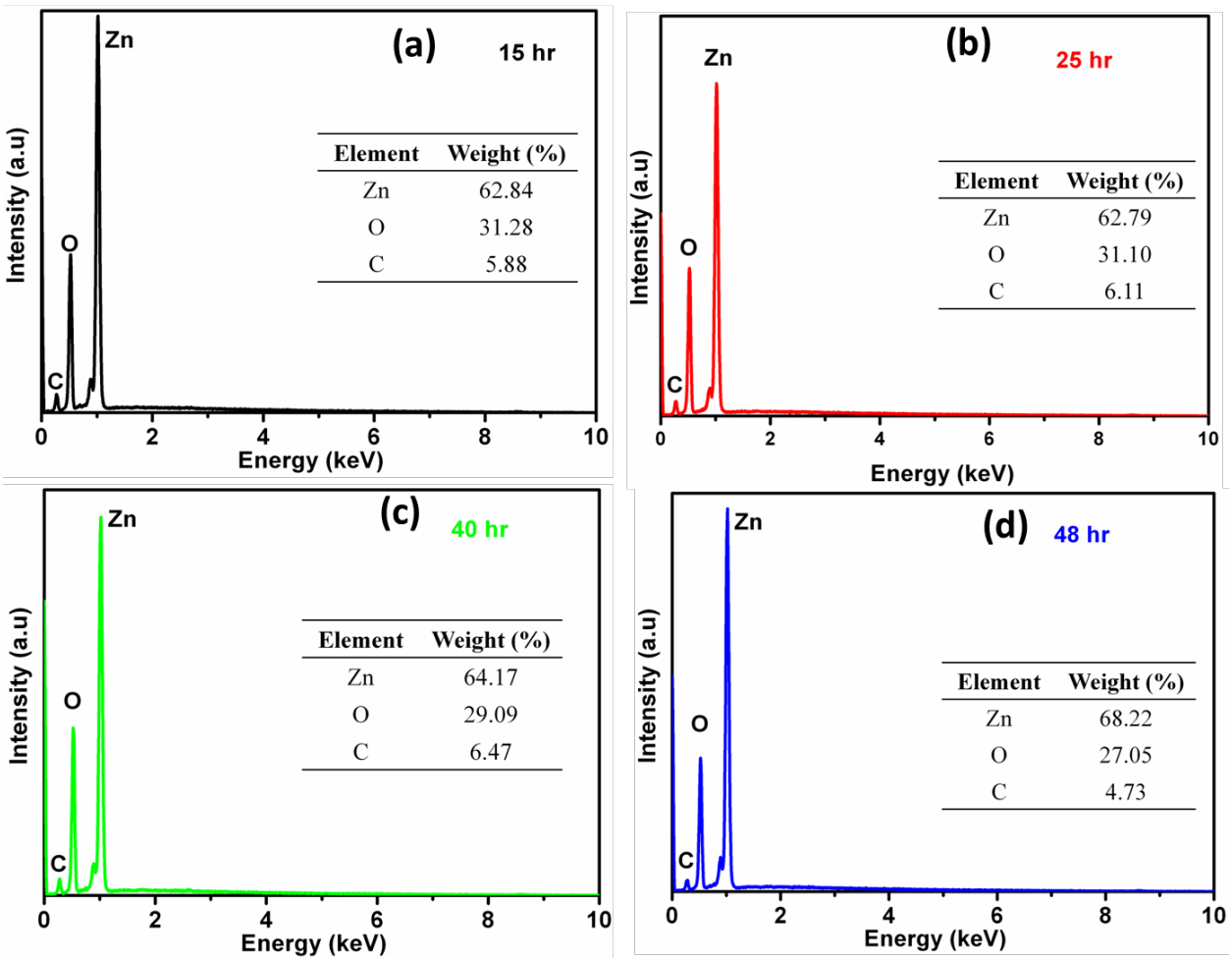


**Fig.4. EDAX spectra and elemental analysis of (a) 15 hr, (b) 25 hr, (c) 40 hr and (d) 48 hr grown ZnO nanostructures.**

## Reference

1.Chunqiao Ge, Zikui Bai, Mulin Hu, Dawen Zeng, Shuizhou Cai, Changsheng Xie, *Mater. Lett.* 2008, **62**, 2307.