# FABRICATION AND CHARACTERIZATION OF ZnO NANORODS

**Nguyen Thanh Binh, Le Thi Thanh Binh, Le Duy Khanh**

*Department of Physics, College of Science, VNU*

**Abstract:** ZnO nanorods were successfully synthesized on Si substrates by the thermal evaporation of zinc powder at 1000 0C. The microstructure of samples was studied by X ray diffraction (XRD) and SEM image measurements. The as-synthesized ZnO rods have the diameter in the range of 80–200 nm. The photoluminescence (PL) spectra of the samples were investigated at room temperature. For all the samples, the luminescence spectra consist of the near band edge emission (~ 380 nm) and a broad green band (~ 500 nm).

## 1. Introduction

In recent year, one–dimensional (1D) nanostructures have attracted a great deal of attention due to their unique properties and potential for future technology. There have been many reports on the synthesis of 1D nanostructure, such as: $SnO_2$ [1], $In_2O_3$ [2], ZnO [3]... These materials have applications in constructing nanoscale electronic and optoelectronic devices.

Zinc oxide (ZnO), which has a direct band gap of 3.37 eV and large exciton binding energy of 60 meV at room temperature, can ensure an efficient exciton ultraviolet (UV) emission at room temperature under a low excitation energy. Several methods have been reported for the synthesis of one – dimensional ZnO nanostructures (nanowires, nanorods, nanobelts) such as: arc discharge, laser vaporization, pyrolysis, electro deposition, chemical vapor deposition and thermal evaporation...

In this work, we have used thermal evaporation method for synthesis of zinc oxide (ZnO) nanorods by annealing zinc (Zn) powder in air at $1000^0$C.

## 2. Experiment

ZnO nanorods were prepared by thermally evaporating zinc powders as source materials. Zinc powders were placed at the bottom of a quartz tube. Several strip – like Si wafers were placed inside the tube to act as the substrates for growing materials. The distance from source materials to the substrates was kept at 2 cm. This quartz tube was rapidly heated to $1000^0$C from room temperature. Subsequently, the furnace was kept at $1000^0$C for an hour and it was cooled to room temperature.

The crystal structures were determined with a Siemens D5005 X ray diffraction (XRD) that used a Cu K$\alpha$ radiation. The morphologies were observed by using JSM 5410 LV scanning electron microscopy (SEM). The photoluminescence spectra were investigated at room temperature by spectrofluormeter FL 3 – 22.

## 3. Results and discussions

Figure 1 shows the XRD pattern of the synthesized sample. All the diffraction peaks show good agreement with those of the hexagonal ZnO with lattice constants a=0.3245nm, c = 0.5208 nm. No diffraction peaks of other impurities were found in any of our samples.

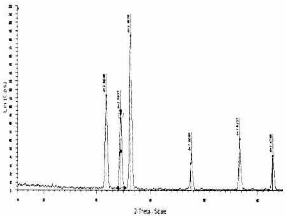

**Fig.1**: XRD pattern of tetrapod-like ZnO nanorods

A typical SEM image for tetrapod-like ZnO nanorods is shown in Fig. 2. The crystals consist of four needles–shaped tetrahedral-arranged legs connected at the center, forming a tetra pod structure. These rods have the diameter in the range of 80-200nm. The length of the legs is in the range of 1-4μm.

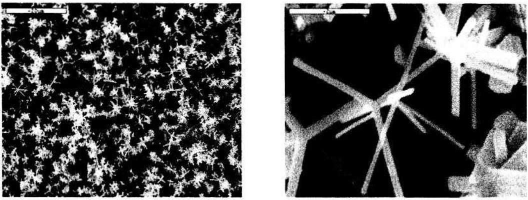

**Fig. 2**: SEM micrograph of tetrapod-like ZnO nanorods on the Si substrate

In general, there exist several mechanisms proposed to account for the growth of 1D structure, including vapor–solid (VS), vapor–liquid-solid (VLS), solid–liquid–solid (SLS) and so on [5, 6]. The VLS mechanism is impossible because no metal catalyst was used and there were no nanoparticle observed on any tips of the legs in our samples. The SLS mechanisms could also be impossible because no solution phase was used in the experiment. Therefore, it is likely that the growth of tetrapod-like ZnO nanorods is governed by the vapor–solid (VS). Herein, at the high temperature, the Zn vapor generated from Zn powders combines with oxygen to form ZnO vapor and which deposit on the substrate.

Photoluminescence spectrum of the sample at room temperature was measured and shown in Fig. 3. For all the samples, the luminescence spectra consist of the near band edge emission (~ 380 nm) and a broad green band (~ 500 nm). The PL intensity depends on preparation conditions. The peak at ultraviolet (UV) region which is around 380nm, is observed by other authors [3, 4, 6, 7]. This peak can be interpreted as exciton recombination [7]. In this paper, we only deal with a broad green band centered at 496 nm. This green photoluminescent emission may be assigned to the presence of oxygen vacancies in the ZnO film [8]. In order to investigate the origins of these peaks, we will measure the PL spectra at low temperature and report next time in the other work.

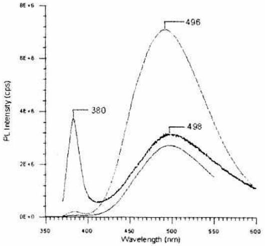


**Fig. 3**: The PL spectra at room temperature $\lambda_{ex} = 300$ nm

## 4. Conclusions

In summary, tetrapod-like ZnO nanorods have been fabricated by thermal evaporation of Zn powder at $1000^0$C via the VS growth mechanisms with lattice constants a = 0.3245nm, c = 0.5208nm. These rods have the diameter in the range of 80 -200nm.

Room temperature PL spectra of the samples showed a UV emission at 380nm and a broad green emission at 496 nm, which was assigned to recombination of exciton and the donor-acceptor pairs, respectively.

*Acknowledgement*

This work is supported by the Project TN 04 - 04

The authors would like to thank Mr. Nguyen Quang Hoa for X-ray measurements and Mr. Hoang Duc Anh for taking the SEM micrographs.

## References

1. [S. H. Sun, G. W. Meng, Y. W. Wang, T. Gao, M. G. Zhang, Y. T. Tyan, X. S. Peng, L. D. Zhang, *Appl. Phys. A* **76** (2003) 287 – 289.
2. F. Zeng, X Zhang, Jin Wang, Lisheng Wang, Lina Zhang, *Nanotechnology*, **15** (2004) 596-600.
3. Seung Chul Lyu, Ye Zhang, Hyun Ruh, Hwack Joo Lee, Hyun – Wook Shim, Eun – Kyung Suh, Cheol Jin Lee, *Chem. Phys. Lett.* **363** (2002) 134 – 138.
4. Y. Dai, Y. Zhang, Q. K. Li, C. W. Nan, *Chem. Phys. Lett.*, **358** (2002) 83 – 86.
5. Q. Wan, K. Yu, T. H. Wang, C. L. Lin, *Appl. Phys. Lett.*, **83** (2003) 2253 – 2255.
6. Xiangying Chen, Changhua An, Jianwei Liu, Xiong Wang, Yitai Qian, J., *Crystal Growth* **253** (2003) 357 – 360.
7. Nguyen Thanh Binh, Le Thi Thanh Binh, Nguyen Ngoc Long, Le Duy Khanh, *Proceedings of the Seventh Vietnamese-German Seminar on Physics and Engineering*, (2004) 210 –214.
8. F. H. Letter, H. R. Alves, A. Hofstaetter, D. M. Hofmann and B. K. Meyer, *Phys. Stat. Sol.* (b) **222,** R4 – R5 (2001).