Field Emission Properties of ZnO Nanorods Arrays

# Natiara V. Madalossi\*,\*\*, Marcos H. M. O. Hamanaka\*, Talita Mazon\* and Italo O. Mazali\*\*

## \*Surface Interaction and Displays Division DSID – Center for Information Technology Renato Archer, Rod. D. Pedro I km 145, 13069-901-Campinas-SP, Brazil

## \*\*Multifunction Materials Laboratory - LMF – Chemistry Institute, UNICAMP, 13083-970, Campinas-SP, Brazil

### ABSTRACT

*A cost-effective and efficient approach for the synthesis of vertically aligned zinc oxide nanorods arrays on Pt/SiO2/Si substrates is presented. ZnO nanorods were grown on Pt/SiO2/Si substrates through the low-temperature wet-chemical batch deposition technique. The scanning electron microscopy image showed that the ZnO nanostructures are successfully grown on the Pt/SiO2/Si substrates surface uniformly. The field emission properties and stability of the fabricated nanostructures also demonstrated great potential for field emission applications.*

### INTRODUCTION

Zinc oxide (ZnO), a wide band gap semiconductor, has exhibited high melting point, excellent chemical stability and negative electron affinity.1,2 Therefore, ZnO is regarded as a potential material in applications of nanoscale electronic devices such as field emission cathodes.

The field emission properties for ZnO nanostructures have been attempted, and their pioneer works demonstrated that the field emission properties of ZnO nanostructures arefairly comparable to those of carbon nanotubes.3 In this work, the authors investigated the field emission performance of the ZnO nanorods arrays prepared by chemical bath deposition.

### METHODOLOGY

The first step of this work was the preparation of a ZnO seed layer on SiO2/Si substrates. The deposition of a zinc citrate on SiO2/Si substrate was made by spin-coating at 3000 rpm for 30 seconds. After there, the substrates were heated treatment at 550° C for 3h. After that, the syntheses of the nanostructures were performed via chemical bath deposition (CBD) by using potassium hydroxide (0.033 M) and zinc acetate (0.033 M) as precursors. The samples obtained were characterized by X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM) and field emission characteristics.

**RESULTS AND DISCUSSION**

The phase composition and phase structure of the synthesized ZnO nanorods arrays were examined by XRD. The diffractogram showed in Figure 1 shows that the peaks originate from wurtizite ZnO structure with preferential orientation along [002] direction.

*.*



Fig 1. *XRD obtained for the ZnO nanorods arrays that was grown on Pt/SiO2/Si by CBD*

The Figure 2 shows the micrographs obtained for the ZnO thin film obtained after the synthesis. It is possible to observe the growing of vertically aligned ZnO nanorods arrays.

natae_002.tif

Fig. 2 *Micrographs obtained by FE-SEM from: ZnO nanorods arrays that was grown on Pt/SiO2/Si by CBD.*

The Figure 3 dislays the variations of emission current versus the applied electric field for the ZnO nanorods arrays. For the ZnO nanorods arrays the turn on fields are observed to be for the sample 1 higher than 1 V µm-1 (Figure 3.a) and for the sample 2 less than 1 V µm-1 (Figure 3.b). The variation in turn on field and threshold field can be attributed to the melting due to higher current density applied.





*Fig. 3* *Field emission current as a function of the applied electric field obtained for ZnO nanorods arrays that was grown on Pt/SiO2/Si by CBD.*

The Figure 4 shows the micrographs obtained by SEM-FEG for the samples 1 and 2 after the field emission measurements. It can be seen that the higher current density was favorable for the melting ZnO nanorods arrays (Figure 4.a).

natae_005.tifNatemissao2_006.tifNatemissao2_005.tifnatae_006.tifnatae_008.tif

Fig. 4 Micrographs obtained by SEM FEG for the ZnO nanorods arrays after the field emission measurements. (a) and (b) Sample 1; (c) and (d) Sample 2.

**CONCLUSIONS**

It was possible to prepare ZnO nanorods devices by CBD method. Efficient field emission indicates that the cathods nanorods of ZnO nanostructures possess good performance with low turn on and threshold fields.

**ACKNOWLEDGEMENTS**

*The authors would like to thanks the LME – LNNano for the support on the SEM-FEG analyses and the FAPESP, CAPES and CNPq for the financial supported.*

### REFERENCES

*[1] R. S. Devan, R. A. Patil, J. Lin and Y. Ma, “One-dimensional Metal-Oxide Nanostructures: Recent Developments in Synthesis, Characterization and Applications”, Materials Views, Vol. 22, pp. 3326-3370 (2012).*

*[2]P. X. Gao, J. H. Song and Z. L. Wang, Advanced Materials, Vol. 19, pp. 67-72 (2007).*

*[3] X. D. Wang, J. H. Song, J. Liu, Z. L. Wang, Science, Vol 316, pp. 102-105 (2007).*

(d)

(c)

(b)

(a)