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Zinc Oxide Nanorod Growth on Au-coated Silverwire

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Abstract: *In this study, zinc oxide nanostructures were grown on gold-coated silver wires by hydrothermal method. Multiple analyses on these nanostructures were performed to understand the structure and optical properties of zinc oxide on Au-plated silver wires, Owing to the Au-coated layer, ZnO nanorods could appear rather than ZnO nanoflakes on pure silver wires. Moreover, The deposited gold layer could vary zinc oxide nanostructures to nanorods The multiple analysis shows that lying flat ZnO structures with weak (002) crystalline structures and more defects could appear on the silver wire rather than ZnO nanostructures on pure silver wires.*

Keywords: ZnO nanorod, hydrothermal method, Au-coated silver wire, defect

1. INTRODUCTION

Nowadays, zinc oxide nanostructures [1] have been intensively studied due to their excellent electronic, material, and optical properties. Therefore, plenty ZnO nanostructures-based semiconductor devices such as gas or light sensors [2], antibacterial [3],and LEDs [4] have been proposed within the decade. In addition, many studies related to various zinc oxide nanostructures on metal substrates or non-conductive plate substrates have been reported [5,6,7]. However, few research reports on the nanostructures on metal wires [8]. In this research, the metal silver, which has a high conductivity and high thermal conductivity, were used as a base to grow ZnO nanostructures. Compared with previous studies [9,10,11], an Au layer was coated on silver wires [12,13].Furthermore, to characterize the nanorods on the Au-coated silver wires, multiple analyses including X-ray diffraction (XRD), chemical analysis (ESCA), photoluminescence (PL) and Raman spectroscopy (Roman) were used to examine the nanostructures. Results indicate that zinc oxide with different nanostructures appeared on Au-coated silverwires. The deposited gold layer could vary zinc oxide nanostructures to nanorods The multiple analysis shows that lying flat ZnO structures with weak (002) crystalline structures and more defects could appear on the silver wire rather than ZnO nanostructures on pure silver wires [14,15,16]. The ZnO nanorods on Au-coated silver wires can be applied in the future ZnO-related line-shaped device applications.

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2. EXPERIMENTAL

In the beginning, we deposited gold on silver wire with e-beam evaporation followed by the deposition of zinc oxide seed layer on the gold/silver wire. The ZnO seed layer was electrodeposited in solutions containing zinc nitrate and potassium nitrate solution with deposition current 18mA for 12 seconds. After that, the substrate containing the seed layer was placed in a solution containing zinc nitrate hexahydrate and hexamethylene tetramine to hydrothermally grow to zinc oxide nanostructures at 80 ° C for one hour. In order to examine the ZnO nanostructure, FESEM was used to view the surface morphology, XRD was used to study the crystalline structures, the PL spectra was used to investigate the optical properties, and ESCA was used to examine the compositions and chemical binding, and the Raman spectroscopy was used to observe the crystal molecular vibration and residual stress.

3. RESULTS AND DISCUSSION

FESEM images as shown in Fig. 1 indicate that ZnO nanorods could be grown on the Au-coated silver wires. Compared with the previous research, only ZnO nanoflakes could be grown on the pure silver wires. Since Au coating could change the interface properties, ZnO nanorods could be possibly grown on the Au-coated silver wires. Furthermore, these nanorods were lying flat on the surface instead of perpendicular growth.

Moreover, to examine the crystalline structures, XRD patterns can be seen on Fig. 2. From the XRD results of the growth direction of ZnO, as shown in Figure 2, ZnO (002) direction peak is

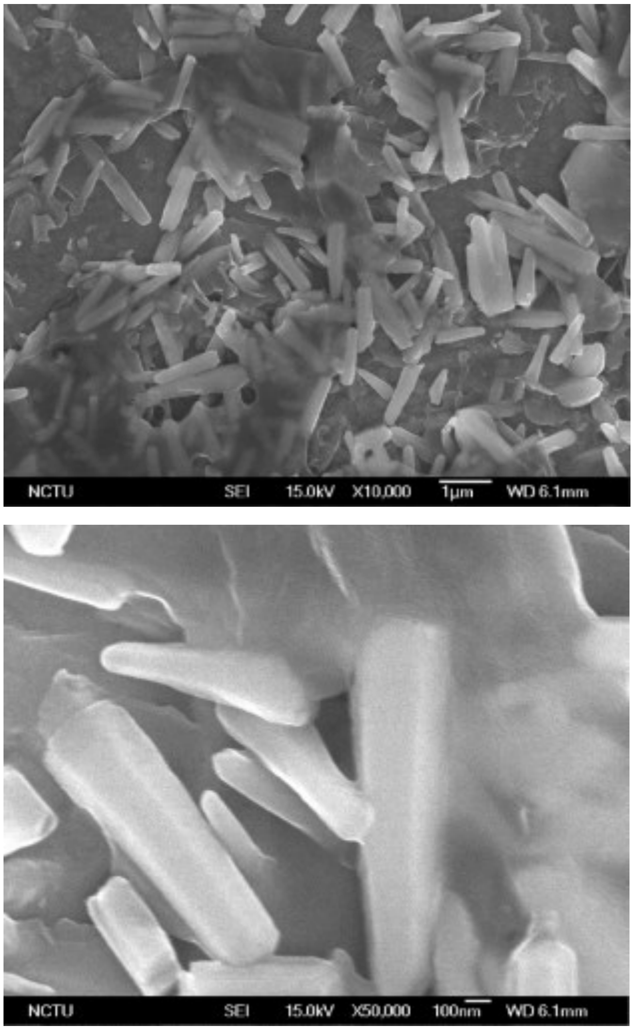


Figure 1.FESEM images of ZnO nanorods on Au-coated silver wire

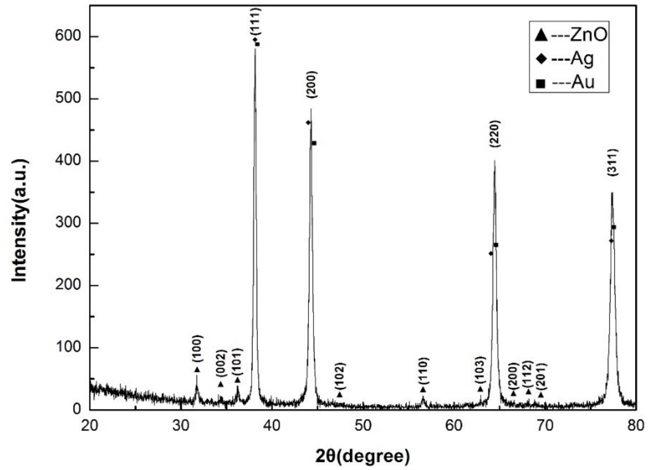


Figure 2. XRD patterns of ZnO nanorods on Au-coated silver wire

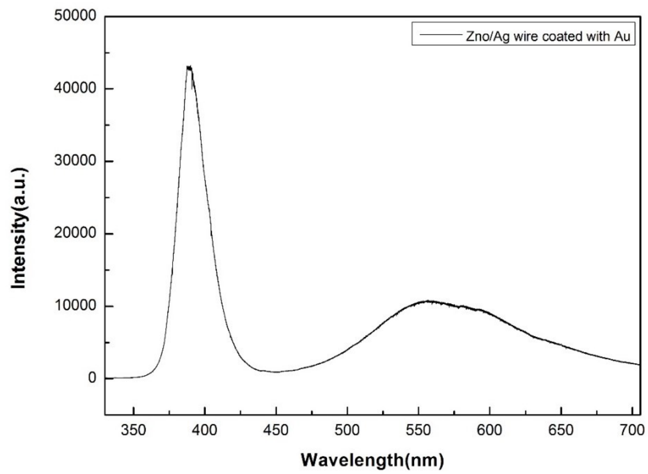


Figure 3. PL analysis of ZnO nanorods on Au-coated silver wire

weak. Therefore, the vertical growth of the ZnO nanorods might not be observed, which is consistent with the FESEM images.

PL analysis as shown in Fig. 3 reveals the optical properties of the ZnO nanostructures. At 389nm, we can see the near band edge emission (NBE) of zinc oxide radiation, while at 556nm we can see the emission of oxygen vacancies related defect. Based on the PL analysis, the defect luminescence was strong. The reason might come from the lying flat of the nanorods. The randomly distributed nanorods might cause more defects inside the ZnO nanostructures. Moreover, the interface between the rod and the Au layer might be responsible for parts of the defects. Compared with the ZnO nanoflakes, which were vertically grown, the defect luminescence were relatively weak.

Then, Raman analysis were performed on these nanostructures. 574 nm is the peak for the ZnO nanocrystal represents C-axis, whcih is parallel to the substrate, while 1145 nm is the peak for multiple photon vibrations and 1726 nm is the peak for the asymmetric multiple photon vibrations.

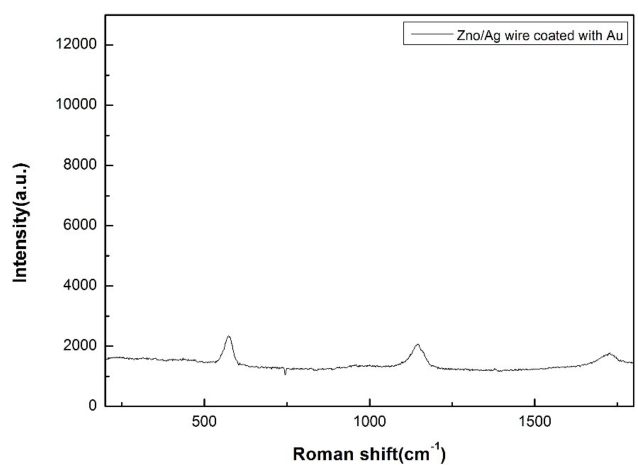
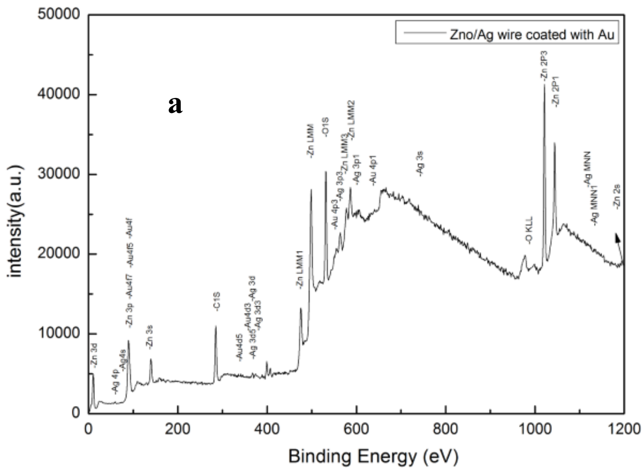


Figure 4. Roman analysis of ZnO nanorods on Au-coated silver wire



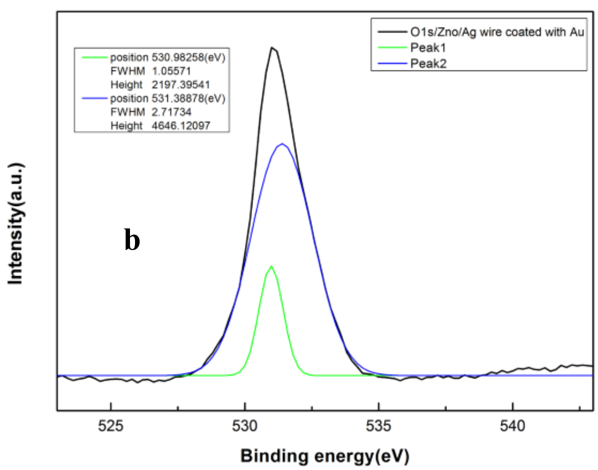


Figure 5. a. ESCA of ZnO nanorods on Au-coated silver wire, b. The O 1s ESCA of ZnO nanorods on Au-coated silver wire

Figure 5-a shows the full spectrum of ESCA, where the peaks of silver, gold and zinc can be seen. In addition, the O1s ESCA diagram of oxygen 1s orbitals with the binding energy of 532 eV for Zn-O-H binding related to the presence of the oxygen-vacancy defects and Zn-O-Zn binding at 531eV for normal growth. The results show that the defect related binding was strong, consistent with previous analysis.

4. CONCLUSIONS

In this study, ZnO nanorods were grown on Au-coated nanorods. Since the nanorods were lying flat, the (002) peak in XRD was weak and the defect luminescence in the PL analysis were strong. Furthermore, the ESCA also indicate the existence of the strong defect related binding. The ZnO nanorods on Au-coated silver wires can be applied in the future ZnO-related line-shaped device applications.

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