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Comparison of ZnO Nanoflakes on Copper and Brass Substrates

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Abstract: *In order to study the difference between two different substrates under different plating currents, we have a relatively small current of the ZnO seed layer at 160mA (current density of 40mA / cm 2) and a current of 12mA (current density of 3mA / cm 2), are plated on copper and brass on the substrate. Then, ZnO nanoflakes were grown on copper and brass substrates by electro- hydrothermal deposition methods. We have done a lot of analysis of the test pieces, including field emission scanning electron microscopy (FESEM), energy-dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD), photoluminescence (PL), and contact angles to compare the differences between the two.*

Keywords: ZnO nanoflakes, hydrothermal method, copper substrate, brass substrate,

1. INTRODUCTION

ZnO [1] is widely used in a variety of applications today because ZnO has many very special properties such as ZnO is a dielectric material with a wide direct energy gap of about 3.37 eV and an exciton binding energy of about 60 meV, mainly used in semiconductors [2], flat panel displays, optoelectronic components and ultraviolet light. Moreover, it can be easily generated for nanostructures, such as quantum dots [3], nanowires [4], nanorods [5,6]and nanoflakes [7,8], which have been widely used in such as electronics [9], medicine [10], optics [4], and so on. Copper, in today's society has been a lot of use, because copper has a good conductive, thermal nature, and does not react with water [11], so the most common use of copper is to make wires, most of the wires used today is made of pure copper. Brass is widely used in power applications [12], power transportation, pipelines and other industrial applications [13] due to its good electrical conductivity, thermal conductivity and mechanical properties. In this study, we used two different currents to lay the ZnO seed layer on the copper and brass plates (a large current of 160 mA and a small current of 12 mA). The plating current provides electrons for the chemical reactions during the process. If the current is too large, because the growth rate may be too fast, it may lead to poor structure. On the other hand, if the current is too small, the lack of electrons may lead to growth failure. We have chosen two suitable currents to make the nanostructures more suitable for deposition on copper and brass substrates. In this experiment, we developed the ZnO nanostructures on copper and brass by hydrothermal method. In order to compare the differences between the two metals and the different current sizes, we have done many analyzes. The results show that with 12mA lower current plating of the seed layer of ZnO nanoflakes in the two kinds of substrate copper and brass in the order of a larger size of the uniform growth of rice-resistant, and it has good hydrophobicity. There are many applications of copper, for example, used to make electrode [14, 15], copper substrate on the ZnO nanoflakes may help to develop the future of the electrode. The brass also has many applications such as various pipelines, the ZnO nanoflakes on the brass substrate that may contribute to the development of future self-cleaning pipelines.

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2. EXPERIMENTAL

Prepare a copper plate having a size of 2 cm x 2 cm and a brass plate as a substrate. In order to deposit the nanostructures on the top of the substrate, the substrate is first polished. As shown below, we use the sandpaper to polish, followed by # 200, # 600, # 600, # 800, # 1000 sandpaper, each of the sandpaper will be used after the substrate rotation 90 º, in order to achieve the goal of polishing substrate. After polishing the substrate, the ZnO seed layer was grown on the polished substrate with an electroplating solution of $Zn(NO_3)_2$ and KNO_3. The electroplating solution consisted of 0.1 M $Zn(NO_3)_2 \cdot 6H_2O$ and 0.1 M KNO_3. The plating current is set to 12mA, respectively, and the larger current is 160mA. Copper, brass substrate area of 2cm × 2cm (4cm^2). When the current is 160 mA, the current density is 40 mA / cm^2. When the current is 12 mA, the current density is 3 mA / cm^2. The temperature of the plating solution was set at 70 ° C. Then, the ZnO nanostructures were thermally deposited at the deposition

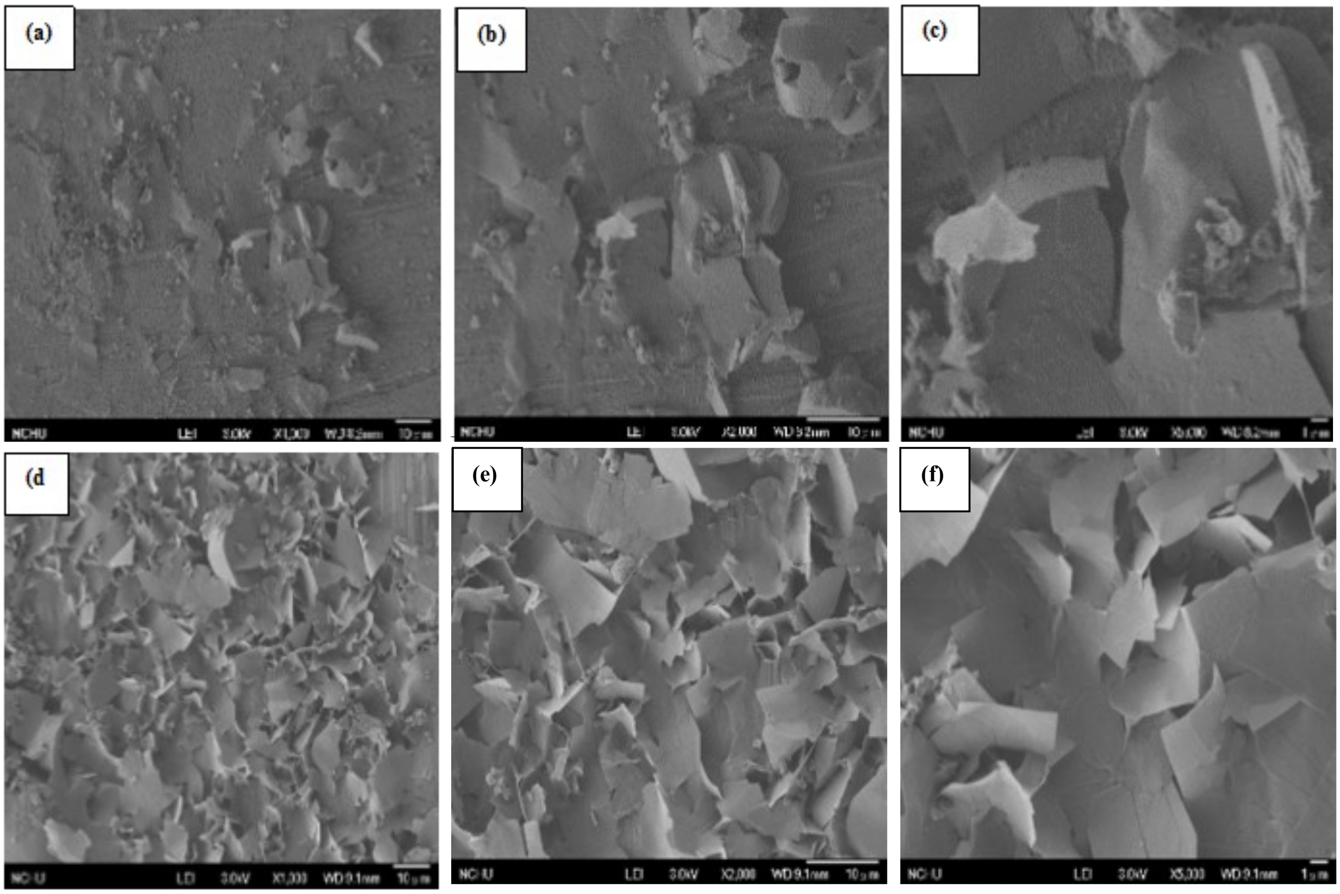

Figure 1. FESEM images of the ZnO nanoflakes with the seed layer grown at a larger current of 160 mA (a)on Cu with a magnification rate of 1000, (b) 2000, and (c) 5000. (d)on Brass with a magnification rate of 1000 , (e)2000 , and (f) 5000.

temperature of 80 ° C for 1 hour at the top of the seed layer. In order to observe the difference of ZnO nanostructures at the top of the two substrates, we used field emission scanning electron microscopy (FESEM) to observe the surface morphology of the test piece and measure the energy dispersive X-ray spectrum (EDX) to study the element composition s difference. In addition, the crystal structure was studied using X-ray diffraction (XRD). In addition, photoluminescence (PL) was used to study optical properties. And contact angle measurements were used to study the hydrophobicity or hydrophilicity of copper, brass-grown ZnO nanostructures on the surface.

3. RESULTS AND DISCUSSION

In order to grow the ZnO nanostructures at the top of the copper and brass plates, we plated a layer of seed layer as an adhesive layer on the substrate. Since we have to study the effect of the seed layer on the two substrates, we have planted the seed layer with a relatively large current of 160 mA and a smaller current of 12 mA. Then, the ZnO nanostructure is hydrothermally deposited on the seed layer. In order to observe the surface morphology of ZnO nanostructures grown under two different conditions, we use FESEM to observe the morphology of ZnO nanometer structure. In the imaging of ZnO nanoflakes, it is possible to see an irregular or chaotic flake-like ZnO nanostructures, and the nanoflakes grown at the seed layer plated at a relatively large current (160 mA) are shown in the lower in the image of the magnification, nanoflakes grown in large areas can be observed. From the image can be found in copper and brass produce a significant difference between the copper substrate in the case of larger current, the growth of the nanometer structure is poor and not obvious, as shown in Fig.1 (a), gradually increased in the magnification, the gradual emergence of some flaky the nanostructures, as shown in Fig.1 (b),(c). In contrast, brass in the larger current (160mA) under the plating of the seed layer of the growth of nanoflakes, the effect is very significant, from the small magnification of the image, you can see a lot of flake-like nanostructure, as shown in Fig.1 (d). In the magnification gradually enlarged under the flaky structure more and more obvious, as shown in Fig.1 (e),(f).

In addition, the nanostructure grown on the copper substrate is more obvious than the high current (160mA) under the electroplating current of the smaller current (12mA), as shown in Fig.2 (a). As the magnification increases, it can be seen that the structure is closer to the nanoflakes, as shown in Fig.2 (b),(c). In the case of brass substrates, it is found that the nanoflakes have a large size and the lamellar structure is more obvious than the larger current at the increase of the magnification, as shown in Fig.2 (d),(e) and (f).

After comparison with the FESEM images, the results show that the small current (12mA) plating conditions on the brass substrate produced on the nanoflake have a more complete and larger size. In addition, in order to analyze the composition of ZnO nanostructures, we measured the energy dispersive X-ray spectrum (EDX),

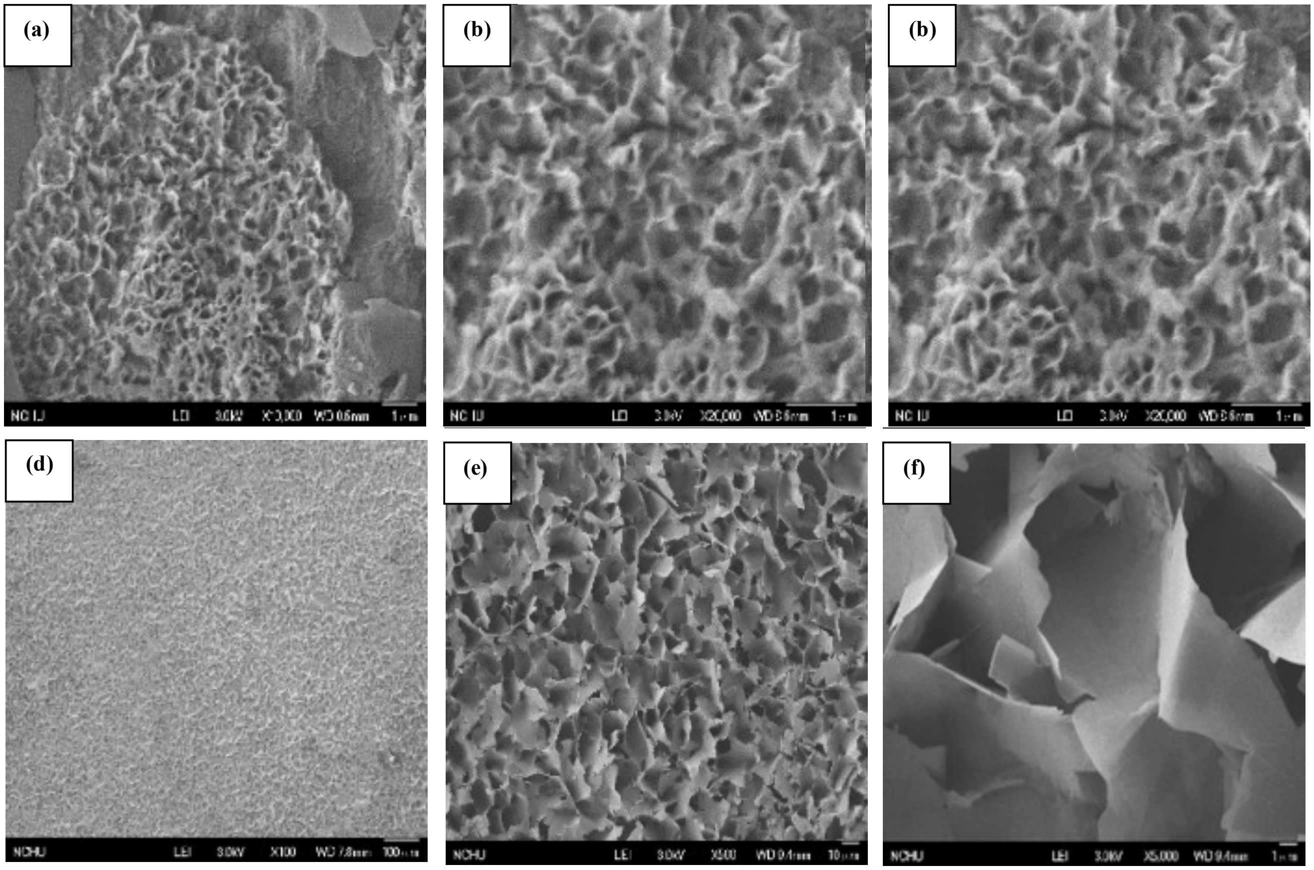

Figure 2. FESEM images of the ZnO nanoflakes with the seed layer grown at a smaller current of 12 mA (a)on Cu with a magnification rate of 10000, (b) 20000, and (c) 50000. (d)on Brass with a magnification rate of 100 , (e)200 , and (f) 5000.

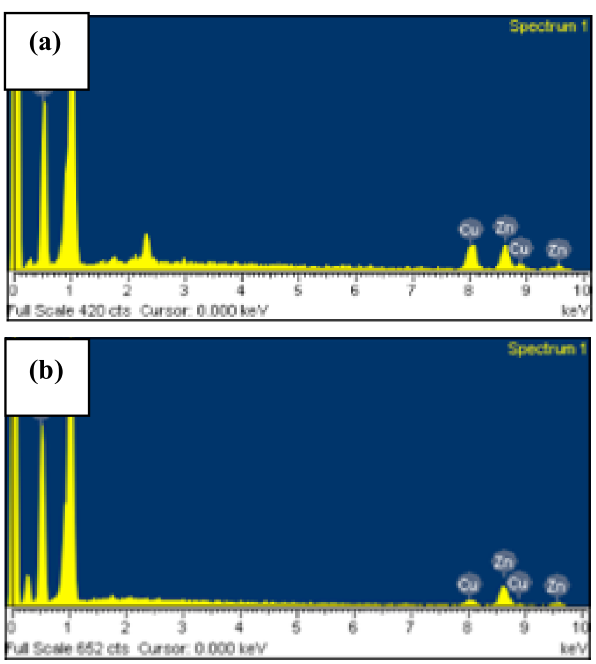

Figure 3. An EDX spectrum of ZnO nanoflakes(a) on the copper plate. (b)on the brass late.

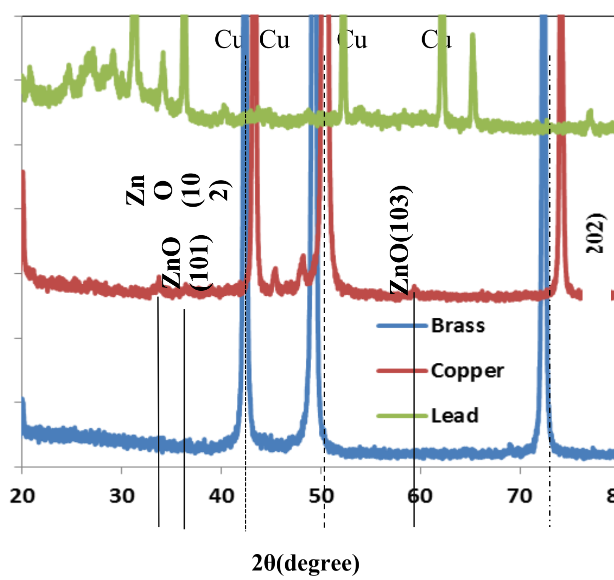

Figure 4. XRD of ZnO nanoflakes with the seed layers grown on cu and brass plate.

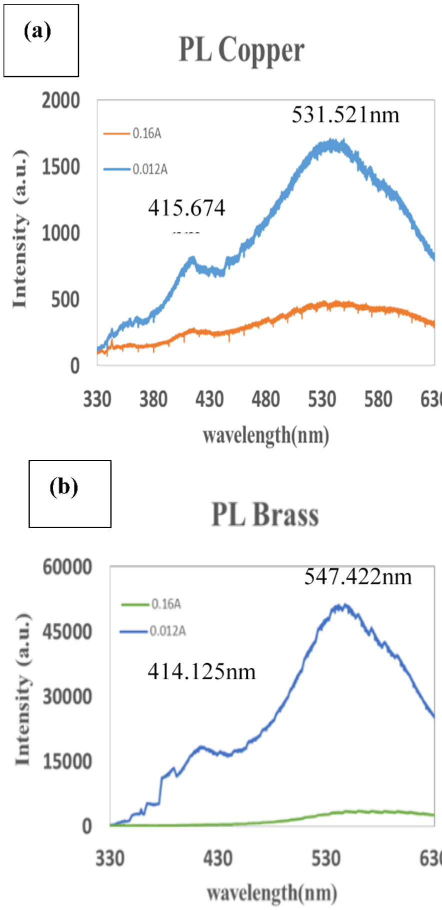

Figure 5. PL spectra of the ZnO nanoflakes with two types of the seed layer (a) on copper plate.(b) on the brass plate.

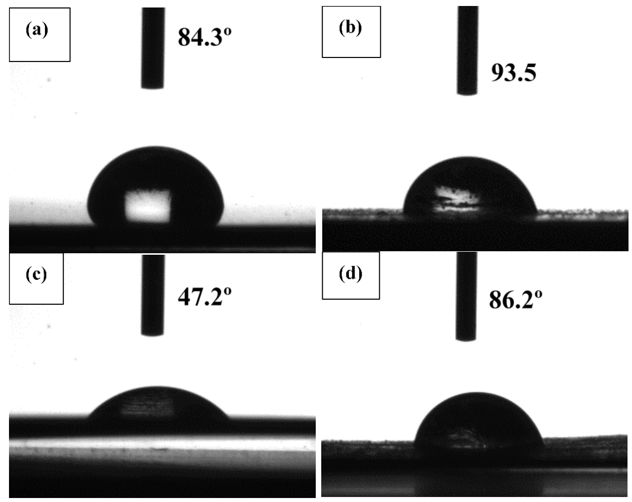

Figure 6. Contact angle measurements for (a) the Cu plate. (b) the ZnO nanoflakes with the seed layer grown on Cu plate. (c) the Brass plate. (d) the ZnO nanoflakes with the seed layer grown on Brass plate.

EDX shows the presence of Zn, O and Cu elements of ZnO nanotubes on copper and brass plates, respectively, as shown in Fig.3 (a),(b).

In order to study the crystal structure of the two substrates, the XRD spectra of the two substrates. The XRD patterns of the two show ZnO (102), ZnO (101), ZnO (103) and strong copper signals, as shown in Figure 4.

In addition, we analyze the optical properties of the two substrates under two kinds of plating conditions. Therefore, we use photoluminescence (PL) to study the optical properties of the two substrates. In the results of PL measurements, we find that the results are in agreement with FESEM. In the image can be found, compared to the large current (160mA), small current (12mA) show a strong flare under the light, and we found that ZnO ultraviolet light peak is small, visible light peak, so to determine the two there are more oxygen vacancies on the test piece, as shown in Fig.5 (a),(b) [4].

Finally, we analyzed the contact angle of the two substrates. It was found that the hydrophobicity of the two kinds of substrates increased after the growth of ZnO nanostructures, but the brass was more obvious than that of copper, as shown in Fig.6 (a), (b), (c), and (d).

According to the previous studies, The higher density of the structure will result in a higher hydrophobicity of the surface, indicating that the density of the nanostructures grown by brass is much higher than that of copper.

4. CONCLUSIONS

ZnO nanoflaks were grown on copper and brass substrates. Each substrate was fabricated using two current conditions (160mA) and (12mA), respectively. In order to compare the differences between the two substrates under different plating conditions, Including FESEM, EDX and XRD, including a variety of analysis. In addition, surface contact angle measurements were performed to study the hydrophobic effect of nanostructures. Since the substrate of ZnO nanoflaks is more hydrophobic than the original metal material, the ZnO nanoflaks / Brass plates can be used for future self-cleaning pipelines[1], while ZnO nanoflaks / Cu plates a new type of electrode for the future can be applied.

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