Fabrication of NiO/PSi for gas sensor application prepared by chemical method

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In this paper NiO$_{NP}$/n-PSi/Si heterojunction for gas sensor has been investigated using chemical method and can show to enhance sensitivity. The structural properties SEM and XRD were synthesis. The sensitivity of NiO/PSi/Si heterojunction for gas sensor to $\text{H}_2$, $\text{N}_2$ and $\text{CO}$ gas was studied. It is obtained a high gas response is clear at 250 $\text{C}$ at low concentration 50 ppm. The NiO NPs depended on the temperature and gas concentration.

**Keywords:** Nickel Oxide; Gas Sensor; Chemical Method; Sensivity; Gas Concentration.

1. INTRODUCTION

Nanomaterials have significant mechanical, electronic, magnetic, thermal, catalytic properties, and optical properties, and have many wide-ranging concerns [1, 2]. Recently, the formation of nanoparticles sized crystalline metal oxides has been a growing interest becusue of their large surface areas, their unique properties, surface defects, and speed of propagation [3]. NiO has cubic lattice structure so it classified as an significant transition metal oxide. Nickel oxide has attracted increasing interest due to potential use in a variety of applications, such as: catalysis, battery cathodes, gas sensors, electro chromic films and magnetic materials. In addition, nickel oxide is widely used in dye sensitized photo cathodes. It exhibits anodized electrochromism, high durability and electrochemical stability, large optical density rotation and other diverse manufacturing potential [4].In addition, nickel oxide semiconductors can be considered as distinct topics and are selected in future studies and research due to of low-cost materials such as ion storage.Due to of the effects of (quantum tunnel and size, volume, surface), it is possible to estimate that nanocrystalline have many improved properties of micrometer-sized nickel oxide particles. [4–8].

It should too be noted that it can be expand many mechanical process or chemical process to compose crystalline oxide powders in nanoscale dimensions. In many of them, the main objective is to reduce the costs of chemical synthesis and to production of materials for
technological applications [9]. The purpose of this work is the synthesis of NiO nanoparticles by the chemical precipitation process. Where, NiO/n-PSi/Si heterojunction of the gas sensor has been investigated using the chemical method.

2. EXPERIMENTAL PROCEDURE

Nickel oxide nanoparticles were prepared by chemical method at 0.1 M Ni(NO$_3$)$_2$.6H$_2$O and 0.2 M of sodium hydroxide NaOH and Urea CO(NH$_2$)$_2$ both of them dissolved in 50 ml double distilled water and mixed under magnetic stirring for 20 min. The precipitate was washing and calcinations at 500 C for 3 hr. In the other hand the NiO NPs deposited n-type of porous silicon by drop castle. Porous silicon fabricated by photo electro chemical etching. The morphology and gas sensor properties have been measured for NiO/PSi/c-Si heterojunction.

3. RESULTS AND DISCUSSION

The X-Ray diffraction of NiO nanoparticles is shown in figure 1. All the XRD peaks are sharp indicating to confirm a good polycrystalline of the oxide with a cubic NiO phase.

![X-Ray diffraction of NiO NPs.](image)

Figure 1: X-Ray diffraction of NiO NPs.

It can be observed the patterns show peaks around (2θ = 29.4°, 37.2°, 43.3°, 62.85°, 75.3° and 79.25°) which are in agreement with (JCPDS) card number (004-0835). The highly intensity peak occurs at (2θ = 43.3°) which is pointed to (200) plane. It can be noticed no other peak related to any impurity. The crystalline size of powder NiO nanoparticles was calculated using scherrer formula was found about (60 nm).

Figure 2 displays the FESEM pattern of powder NiO nanostructure. It is clear that the original morphology of NiO nanoparticles and that a spherical shape but show agglomeration of particles are occurred. The average size of NiO nanoparticles was found 40 nm.
The vibration properties of NiO/NPs/Psi/c-Si nanostructure was investigated by Raman spectra and is shown in Figure 3. It is clear that they have typical characteristics of strong emission and narrow band at 500 cm\(^{-1}\), it is to be noted that the LO mode of NiO/PSi becomes asymmetric in comparison with that of c-Si.

Figure 3: The vibration properties of NiO/Psi/c-Si nanostructure.

Figure 4 displays the sensitivity of NiO/PSi/c-Si sensor for H\(_2\), N\(_2\), CO gases as a function to temperature. It can be observed that the sensitivity of NiO/PSi/c-Si was increased with increasing temperature and it is found that the high value is 70% for H\(_2\) gas at 250\(^\circ\)C.

Figure 4: Sensitivity of NiO/PSi/c-Si sensor for H\(_2\), N\(_2\), CO gases as a function to temperature.
Figure 4: The sensitivity of NiO/PSi/c-Si sensor for H$_2$, N$_2$, CO gases as a function to temperature.

The increasing of sensitivity for gas sensor related to high surface area of NiO/PSi/c-Si and smaller grain size of NiO particles.

4. CONCLUSIONS

NiO Nanoparticles n-PSi/c-Si sensor was synthesized at room temperature prepared by chemical method. The sensitivity of NiO/PSi fabrication structures to 50 ppm of H$_2$, N$_2$, CO gases were studied. Results of measurements showed that it is the sensor response to H$_2$ at low operating temperatures has high sensitivity compared to N$_2$ and CO. Finally, NiO nanoparticles sensitivity was dependence on the temperature.

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References

