Synthesis of Zinc Oxide Nanostructures

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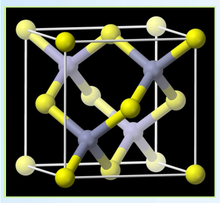
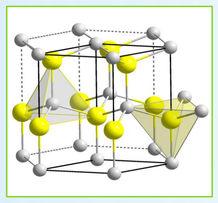
Introduction

- **Zinc Oxide** is:
  - a white crystalline powder with the formula of ZnO
  - Semiconductor with a 3.37 bandgap
  - Insoluble to water/ alcohol; soluble to acids
  - Oxygen loss on heating results in yellow color
  - Sublimes at 1200c and melts at 1975c
  - Hexagonal wurtzite and zincblende structures, with the hexagonal wurtzite structure causing pyro electricity and piezoelectricity



Zincblende structure



Hexagonal wurtzite structure

Nanostructures-minute components that are a few nanometers in size. They are used for nanotechnology including computer chips and gas detectors

The technique we used:
Thermal Evaporation - the sublimation, the act of going from solid to gas, of a substance at a certain temperature and pressure, in which, as the substance solidifies, different structures are formed.

Purpose: The purpose of this experiment is to grow nanostructures and to analyze the characteristics of them

Equipment

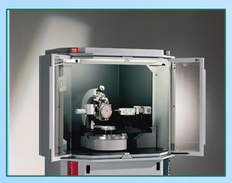
All Equipment:
- Thermal Furnace
- X- Ray Diffraction
- Scanning Electron
- Microscope
- Transmission Electron Microscope
- Photoelectron Spectroscopy

The equipment we used was the Thermal Furnace, SEM, and XRD

- The thermal furnace is a tube furnace used to heat the ZnO
- Scanning electron microscopes (SEMs) are microscopes that create an actual image of the substance by using electrons
- X-ray diffraction (XRD) is the scattering of x-rays by crystal atoms, which give information about the crystal

Thermal Tube Furnace

Scanning Electron Microscope



XRD machine

Experimental Procedure

Silicon Substrates

- 111 silicon substrates were utilized
- Carbon was mixed with the ZnO in order to lower the sublimation temperature
- Powder was then placed the corner of a ceramic rectangular container
- Substrates were cut and placed into the MTI thermal tube furnace.
- Ceramic container was pushed 20 cm. into the MTI thermal tube furnace
- Temperature was set to 700c and was increased by 50c per trial until the desired temperature of 900c was reached
- The furnace warmed up for 20 minutes and ran at the desired temperature for 40 minutes
- The furnace was shut off in order to cool, and after it cooled the components were taken out and put in a container
- The samples were analyzed by XRD and SEM

Results and Discussion

Parameters :
- Argon flow -50 standard cubic centimeters per minute (sccm)
- Temperature of 900c for 40 minutes
- ZnO ratio of 4g to 1g
- Pressure of 0.04 Mega Pascals (mpa)

X-ray Diffraction

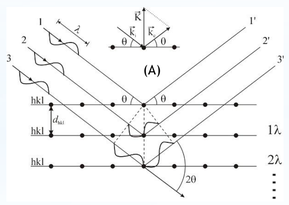


Figure A and B: A shows how the x-rays bounce off the sample and is detected. B shows the XRD of pure powder.

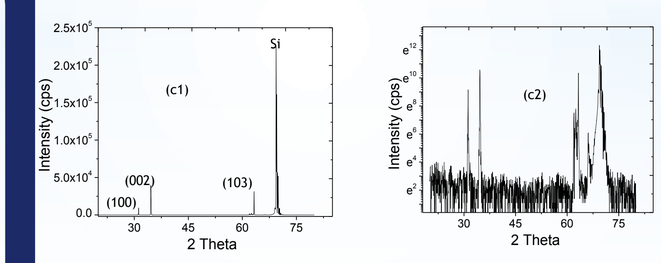
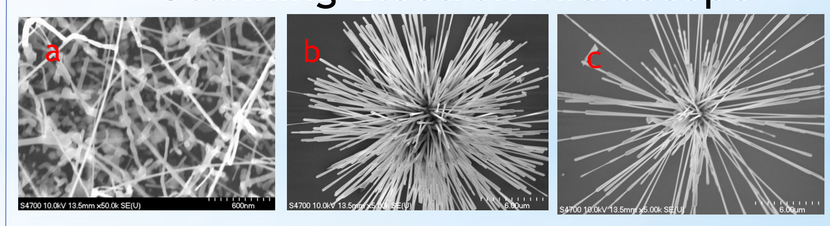


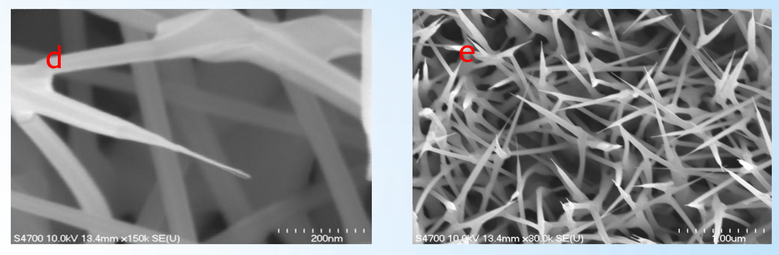
Figure c1 and c2: X-ray diffraction of ZnO nanostructures. Figure c2 is a logarithmic of figure c2 to show all hidden peaks.

This XRD pattern shows that the structures are ZnO, with 002 the preferred growth direction.

Scanning Electron Microscope



SEM images of ZnO nanostructures Figure a: Nanorods, etc. Temperature used was 750c Figure b and c: NANOFLOWERS- a combination of many different nanowires combined together. Temperature used was 900c



Figures d and e
NANOSWORDS- nanorods with a sharp pointed end. Temperature used was 800c

Conclusion and Future Work

Our results indicated that the different parameters we used to synthesize Zinc Oxide Nanostructures resulted in nanorods, nanowires (thinner nanorods) nanoswords, and nanoflowers. This shows that the parameters, such as temperature gradient, Argon gas flow rate, and the pressure affected the morphology of the structures. It is essential to note that temperatures of 900°C and pressure in the region of 0.04MPa were required for a successful ZnO nanostructure synthesis. In the future, I would like to use other oxides such as gallium oxide in order to make nanostructures and compare the characteristics as well as to use oxygen gas in the creation of ZnO nanostuctures.

References

(1)nanoscience.gatech.edu/paper/2004/0-JP_1.pdf (2) www.dictionary.com (3) www.understandingnano.com/nanotech/zinc/zinc_oxide.html

Acknowledgments

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