Growth of Zinc Oxide Nanostructures On Silicon (100)

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Introduction

Zinc Oxide is a compound of Zinc and Oxygen which can be represented by the formula ZnO. It has a powdery, light consistency. It is insoluble to water and alcohol, yet it is soluble to acids. It has two states in which it crystallizes: wurtzite and zincblende. It is also a semiconductor. It has a melting point of 1,975°C and a sublimation point of 1,200°C. It has a band gap, area referring to the polarity of energy between the valence band and the conduction band, which has a size of 3.37 eV which allows it to absorb large amounts of energy.

Nanostructures are objects that are a few nanometers in size; in essence, they are extremely small. There are many different types of nanostructures such as nanowires, nanobelts, nanocombs, and nanorods etc. Despite their size, they can be used in a number of ways including its involvement in medicine and modern day technology.

Purpose of study is to successfully grow pure Zinc Oxide nanostructures and to find out the effect that the orientation of silicon has on the growth of them.

Thermal Evaporation is a sublimation technique that allows substances to go from a state of solidity to a gas form in which the atoms of that substance are free and not as compact.

Experimental Procedure

- Silicon substrates with an orientation of 100 were cut and cleaned.
- ZnO and Carbon were mixed together and placed in the corner of a ceramic tub.
- One substrate was placed into the ceramic tub. The ceramic tub was placed 20 cm into the furnace which was followed by three other substrates that simply sat in the tube.
- A pump was then connected to the furnace and it was responsible for removing pressure from the furnace.
- Once the desired pressure of 0.04 mpa was reached in the furnace, Argon gas was flown through the furnace at a rate of 50 standard cubic centimeters per minute (sccm).
- The furnace was then set to 700°C for the first trial and was increased 50°C each trial until we reached 900°C
- Due to the amount of time it takes the furnace to cool, the samples were taken out the next day and were placed in containers.
- Afterwards, the samples were taken to the X- Ray Diffraction machine (XRD) and to the Scanning Electron Microscope (SEM).

Equipment

- Thermal Furnace: This is a furnace that exceeds the temperatures of regular furnaces and it was used to heat the ZnO and Carbon.
- X- Ray Diffraction Machine (XRD): a machine that allows for X- Ray diffractions, the dispersion of X-Rays by crystal atoms, to be done on substances (mainly powders) in order to study the structure and arrangement of atoms.
- Scanning Electron Microscope (SEM): This is a microscope that uses electrons instead of light to produce an image. The images produced by the SEM have a high resolution which allows for samples to be magnified to a greater extent.

Results & Discussion

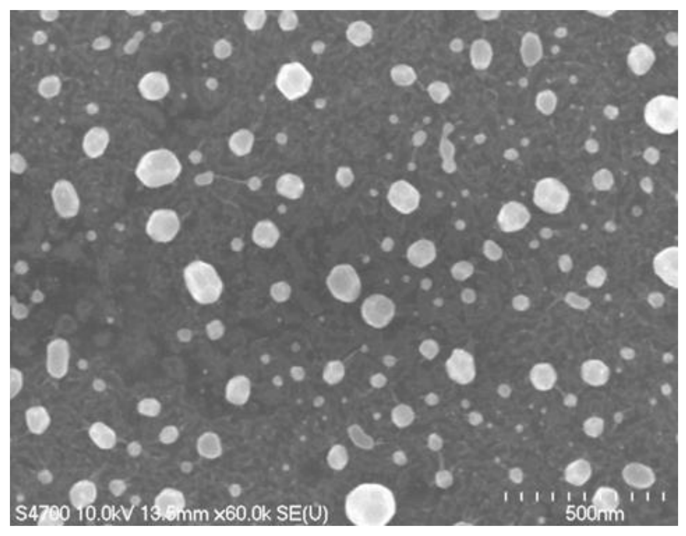


Figure1.
Parameters:
- Argon Flow Rate: 50 sccm
- Pressure: 0.04 mpa
- Time: 40 minutes
- Temperature of Furnace: 750°C
- Ratio of ZnO:C:1g:1g
- < 100 Silicon Chip> Nanostructure Grown: None; particles

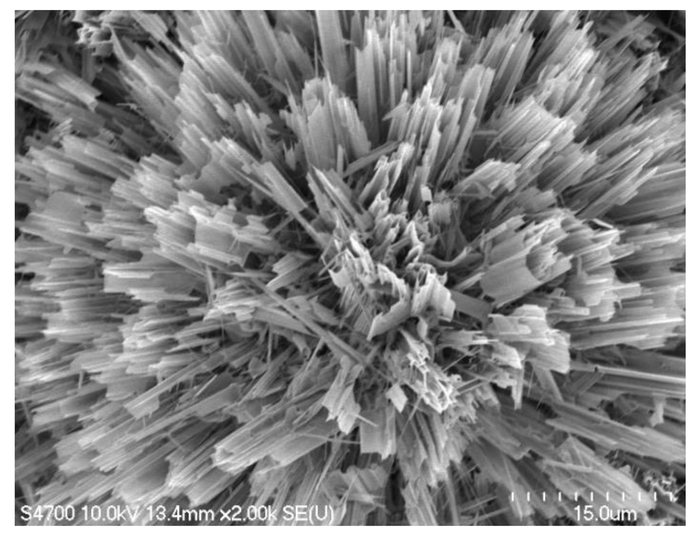


Figure2.
Parameters:
- Argon Flow Rate: 50 sccm
- Pressure: 0.04 mpa
- Time: 40 minutes
- Temperature of Furnace: 900°C
- Ratio of ZnO:C:4g:1g
- < 100 Silicon Chip> Nanostructure Grown: Nanoflower

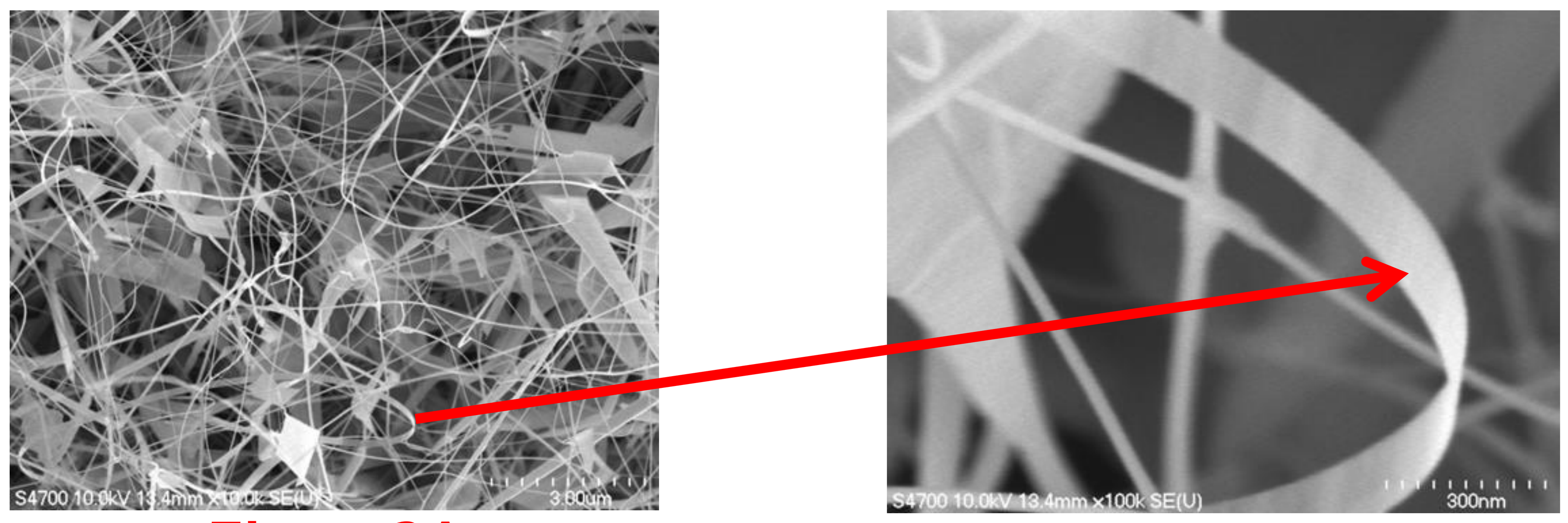
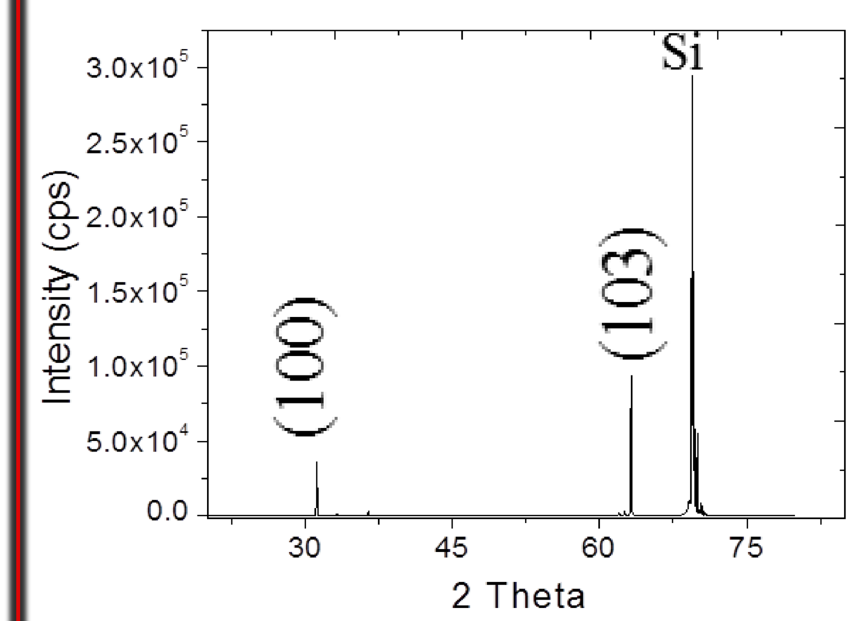
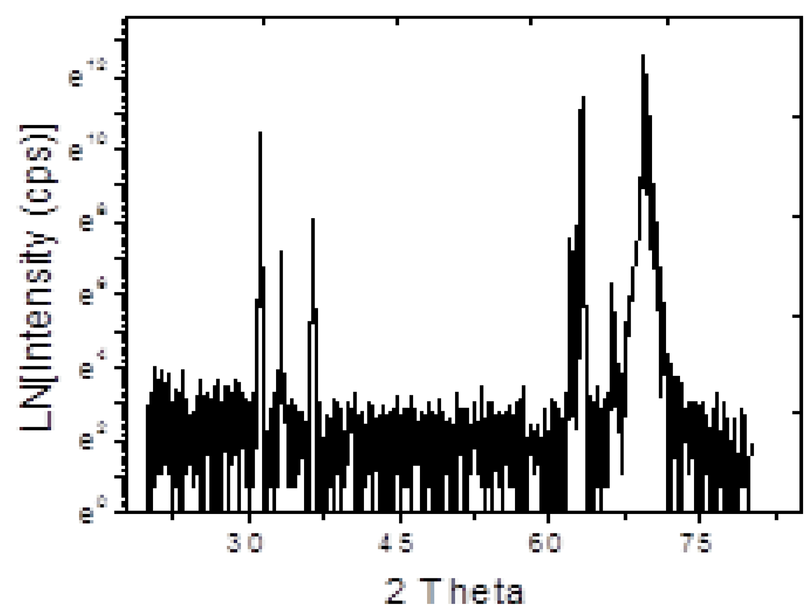


Figure3A. **Figure3B.**

Parameters:
- Argon Flow Rate: 50 sccm • Pressure: 0.04 mpa • Time: 40 minutes
- Temperature of Furnace: 800°C • Ratio of ZnO:C:4g:1g
- < 100 Silicon Chip> • Nanostructure Grown: Nanowires and Nanobelts





These XRD patterns show that 103 was most dominant direction that the nanobelts grew in. They also show that the nanostructures grown are pure ZnO. Lastly, they show that that the bonds between zinc and oxide weren't broken; otherwise, peaks from Zinc would've shown in the XRD patterns.

Conclusion and Future Work

- Our results show that the temperature at which the nanostructures were synthesized and the position of the silicon substrates affected which nanostructures were actually grown.
- The ratio of ZnO:C and the total quantity used affected the size of the nanostructures.
- Generally, the structures follow the orientation of the substrate, but my results show (103) was the preferred growth direction.
- In the future, I would like to repeat this process not only with Argon but with other gases and also grow other structures other than ZnO.

References

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Acknowledgments

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I'd like to dedicate this poster to my loving mother, Ardren Deberry.