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# ZnO nanostructures grown by thermal CVD: Synthesis and Characterization

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**Abstract** – The growth ZnO nanowires using Zn and $O_2$ as source materials is reported. Our synthesis was based on a vapor-liquid-solid (VLS) mechanism via thermal chemical vapor deposition (CVD). We synthesized the zinc oxide nanowires by the VLS mechanism using gold as a catalyst. The silicon (Si) substrates with 5 nm gold (Au) thin films were placed downstream from the crucible, and served as the platform for nanowire growth. The growth properties were studied as a function of growth temperature and oxygen partial pressure.

The semiconductor ZnO, which has a wide gap of 3.37 eV (at room temperature) and a large exciton binding energy of 60 meV, has been recognized as a promising photonic material in the blue-UV region. It also has use as a piezoelectric and transparent conducting material, and potential as a diluted magnetic semiconductor. Therefore, the ZnO nanowire has become one of the most promising elemental building blocks in nanotechnology applications [1].
Zinc oxide films were grown on (100) silicon substrate using a simple three-zone furnace approach. The precursors to synthesize the ZnO were the metal Zn vapor and $O_2$ gas.The apparatus used in this study is schematically illustrated in Fig. 1. The growth reactor was a quartz tube (100 cm in length and 38 mm in diameter). The horizontal furnace consisted of three temperature zones; one was used for heating the substrate and the other was for vaporizing high purity Zn powder (Alfa Aesar, purity 99.99%). The argon gas was employed as the carrier gas to transport the Zn vapor from the Zn vaporization zone to the deposition zone. $O_2$ flux was introduced directly into the deposition zone through a quartz tube. A 1x1cm$^2$ piece of (100) silicon wafer with 5 nm gold (Au) thin-films were placed downstream from the crucible, and served as the platform for nanowire growth.
The substrate temperature (3$^{rd}$ zone) was varied in the range from 600 to 800 °C and the growth time was about 30 min. The temperature for vaporizing the Zn powder (2$^{nd}$ zone) was kept at 400°C. The flow rate of the argon carrier gas for Zn was fixed at 100 sccm. A flow of 100 sccm of argon was used as the carrier gas to help evaporate Zn powder. The flow rate of oxygen was varied in the range of 0.5 sccm to 5 sccm. The base pressure in the quartz tube reactor was maintained at ~0.25 torr. Fig. 2 shows a representative SEM plan view image of the ZnO nanowires. The inset shows a TEM image of typical ZnO nanowires. The typical length of the resulting nanowires was about 2 µm, with diameters in the range of 50–100 nm.

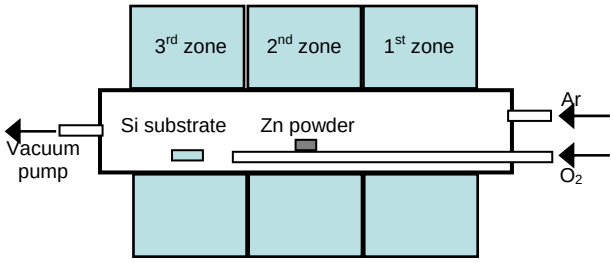


Figure 1. Schematic of the 3-zone growth apparatus consisting of a 38 mm diameter quartz tube in a 3-zone tube furnace.

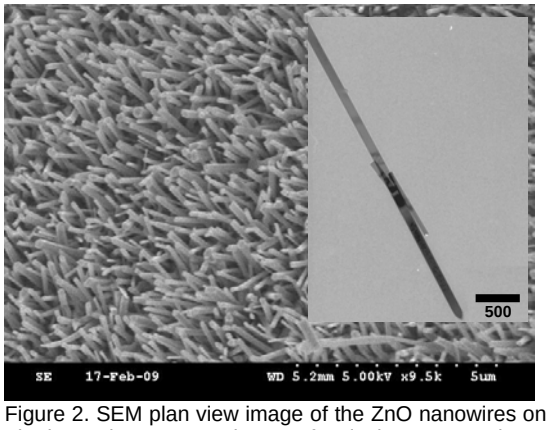


Figure 2. SEM plan view image of the ZnO nanowires on Si(001). The inset shows a TEM image of typical ZnO nanowires.

## References

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