

## Growth and Characterization of Nanowires and Nanorods on Al<sub>2</sub>O<sub>3</sub>(110), Si(111) and SiO<sub>2</sub>/p-Si(100) by MOCVD

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We report growth of ZnO nanowires and nanorods using an atmospheric pressure, horizontal MOCVD, without any metal catalyst. The ZnO structures were grown on sapphire (110), Si(111) and SiO<sub>2</sub>/p-Si(111) substrates by controlling the ZnO precursor flow, growth temperature and distance from the injector. Prior to the growth of the nanostructure, a thin film of ZnO was grown at 400°C for 2 mins, DeZ was used as ZnO precursor with a flow rate of 200 sccm, N<sub>2</sub>O was used as oxygen source with a flow rate of 50 sccm and N<sub>2</sub> was used as the carrier gas.

Figure 1 shows vertically aligned ZnO nanowires grown on sapphire (110) using DeZ at 650°C. The oxygen flow was kept constant at 50sccm. The nanowires have sharp tips with a clean surface and an approximated diameter of 30 – 70 nm.

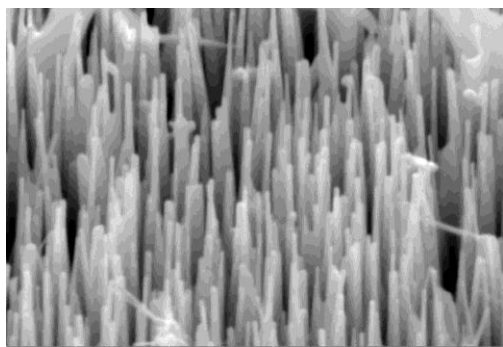
Figure 2 shows randomly oriented ZnO nanowires grown on Si(111) a DeZ flow rate of 20sccm, an oxygen flow rate of 50sccm at 625°C. The nanowires have a pencil-kind of shape with hexagonal tips and an approximated diameter of 400 – 600 nm.

Figure 3 shows mostly vertically aligned ZnO nanorods grown on SiO<sub>2</sub>(1400Å)/p-Si(100) with a DeZ flow of 20sccm, an oxygen flow of 50sccm at 625°C. The nanorods have round tips, a not well-cleaned surface and an approximated diameter of 180 – 200 nm.

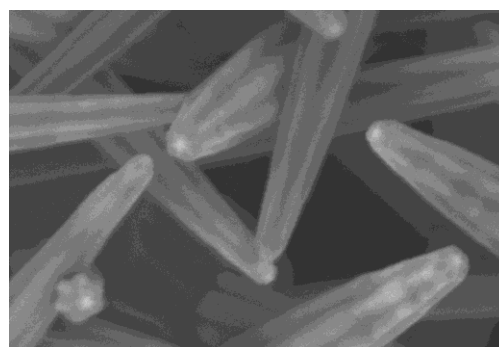
Figure 4 shows XRD taken on the three samples. ZnO/Al<sub>2</sub>O<sub>3</sub> has the highest quality and less residual stress, with a dominant peak at 34.46° (2θ) corresponding to ZnO along 002, a FWHM of 0.0830°(θ) and a c-lattice constant of 5.2011Å. The low FWHM is indicative of good crystal quality, typical value reported for ZnO NW grown on sapphire (001) is in the range of 0.1° – 1°(θ). The c-lattice constant is close to the relaxed c-lattice constant of ZnO (5.204x10<sup>-10</sup> JCPPS card No. 36-1451), confining the growth along 002 direction as shown in Figure 1. ZnO/Si(111) has a dominant peak at 34.53°(2θ) associated to ZnO along 002, a FWHM of 0.0922°(θ) and a c-lattice constant of 5.1909Å. The high stress seen in the ZnO c-lattice constant is due to the large lattice mismatch (~ 40%) between Si and ZnO, contributing to the random orientation of the nanowires. ZnO/SiO<sub>2</sub>(1400Å)/p-Si(100) has a shallow peak at 34.39°(2θ) assigned to ZnO along 002, a FWHM of 0.0921°(θ) and a c-lattice constant of 5.2115Å. It also has small peaks associated to ZnO along 100, 101, 103 and 200, possibly related to the amorphous surface of SiO<sub>2</sub>.

## References

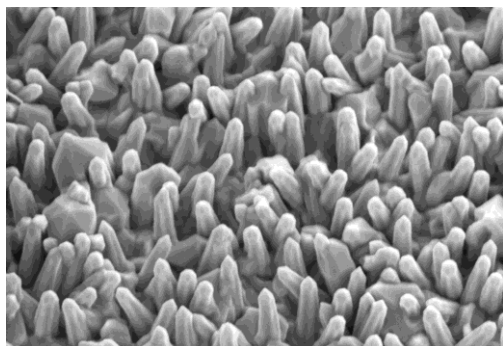
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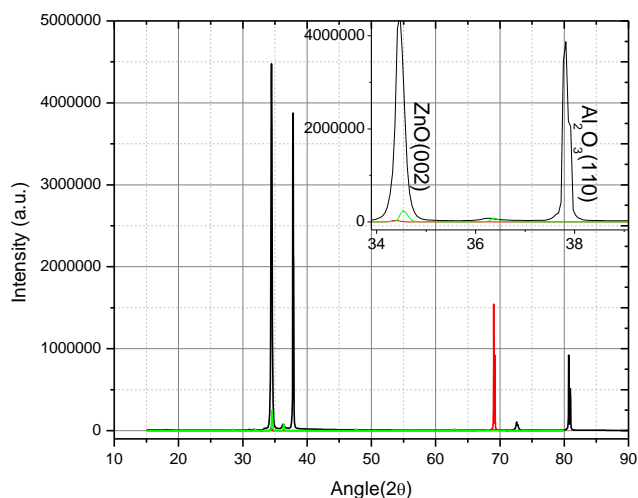
**Figure 1 - Vertically Aligned ZnO NWs grown on Sapphire (110)**



**Figure 2 - Randomly Oriented ZnO NWs grown on Si(111)**



**Figure 3 - Vertically Aligned NRs grown on SiO<sub>2</sub> (1400Å)/p-Si(100)**



**Figure 4 - XRD for ZnO nanowires on sapphire (110) (in black), ZnO on Si(111) (on green) and ZnO nanorods on SiO<sub>2</sub>(1400)/p-Si(111) (on red). Inset Zoom in from 34° to 39°**