Schottky Contacts on Polarity-Controlled Vertical ZnO Nanorods

Supporting Information

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Electrical measurement experimental observations of polarity-controlled nanorods

It was found in the as-grown state that stable and low-resistance contacts to the sides of the nanowires were not achievable due to the residual surface HMTA contamination that is present after the wet-chemical growth method. Current of only several nA’s was recorded at ±2 V with a seemingly random range of ‘S-shaped’ and asymmetric current-Voltage (I-V) characteristics, in agreement with Brillson et al. However, these contacts were not stable and would vary between each measurement. The initial testing of the side contacts showed that a greater conductivity could be achieved when the probes were placed on a side apex conjoining the (0110) facets or at the uppermost apex of the (0110) facets and the (0001) or (0001) top facet presumably due to the more defective nature at these junctions. When a low-resistance side contact was possible the second probe on the top polar facet measured a range of behaviour from high-resistance linear I-V (with current of the order 10-100 nA’s at ±1V) to asymmetric Schottky-like characteristics registering current 10 nA - 1 μA at +1 V.

In an attempt to remove the HMTA but without substantially affecting the nanorods, a short 20 seconds oxygen plasma treatment was used to modify the electronic state of the surface layers which allowed stable higher conductivity probe contacts to be formed to the sides of the nanorods. This is thought to be a result of reactions with surface contamination and adsorbed gases and water. The 20 sec oxygen plasma treatment produced low-resistance contacts on the nanowire side facets giving linear I-V behaviour with current values in the range of 20-50 μA’s between the probes which provides an approximate two-probe resistivity of 0.1 Ωcm, greater than the four-probe resistivity. It was then found that placing a probe on the top polar facet the current reduced to only several tens of nA’s at +1 V with weakly rectifying characteristics. No distinct difference could be discerned between the two nanorod terminating polar facets although
measurements were variable. It was unclear whether the high resistance polar contacts were due to an electrostatic effect that was observed by SEM, shown in Figure 1a as a contrast effect, or an effect of the polar facets forming poor contacts with the point contact probes, while it is still possible there was persistent contamination that was more tightly bound to the polar surfaces. It was evident that the polar facets were quite different from the side facets. Depositing Au on the top facets overcame the variable nature of the probe contact on the top facets and the I-V data measured from the samples after the 20 sec plasma treatment resulted in values of $\phi_e \sim 0.2 - 0.3$ eV and poor thermionic emission fit with values of n~10. This was reflected in the low rectification ratios of the Zn-polar nanorods of 2 to 15 and O-polar nanorods with slightly greater $RR$ ranging from 3 to 40.
Figures

Figure S1. Plots of (a) effective barrier height and (b) rectification ratio against the resistivity estimated from the I-V data near +2V.

References
