Defects and Electrical Characteristics of Pt-based Ohmic and Schottky Contacts to ZnO Nanowires

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Zinc oxide has emerged as a promising wide bandgap material (3.35eV at 300K) for use in next-generation nanoelectronics, with important piezoelectric, gas sensing, and optoelectronic (UV) properties. We report the *in-situ* fabrication of both Ohmic and Schottky contacts to single ZnO nanowires prepared by pulsed laser deposition (PLD) and carbothermal vapor phase transport, using only Pt metal and Ga-ion surface modification.

In bulk ZnO, defects have been shown to strongly affect the behavior of metal contacts, by modifying band bending and allowing trap-assisted tunneling transport through the metal-ZnO Schottky barrier [1]. A Ga focused ion beam (FIB) was operated at 30 keV to implant NW surfaces before metallization for creation of Ohmic contacts, and at 5 keV to gently mill the outer annulus and reduce defect concentrations at the surface, promoting formation of Schottky contacts. Electron beam induced deposition (EBID) was used to pattern Pt metal contacts to the wires, and current-voltage characteristics were measured. Depth-resolved cathodoluminescence spectroscopy (DRCLS) was used to measure native point defects at the nanowire surface, into the bulk, and under 30nm Pt contacts. Depth profiles of DRCL spectra at and under Ga-implanted Ohmic contacts reveals interfacial segregation of copper on zinc site defects (Cu_{Zn}, 2.34eV) and oxygen vacancies (V_O, 2.54eV). Ohmic contact resistivity was also found to decrease with increasing 30 keV Ga-implantation dose. A depth profile of DRCL spectra at the interface of a Ga-milled area and 30nm Pt contact demonstrates that milling of the NW surface decreases concentration of Cu_{Zn} by an order of magnitude, promoting the formation of Schottky contacts. A Schottky contact with 2 orders of magnitude rectification was fabricated to the thin end of a tapered NW, whose diameter increases linearly from 400nm to 1μm at the other end. Investigation of defect dependence on NW diameter also demonstrated a 2x linear increase in Cu_{Zn} from 500nm to 1μm diameter. To cause pinch-off, the depletion width must be comparable to the NW diameter [2]. Thus, thinner wires are easier to pinch-off and have a lower inherent concentration of surface defects, promoting easier formation of Schottky contacts.

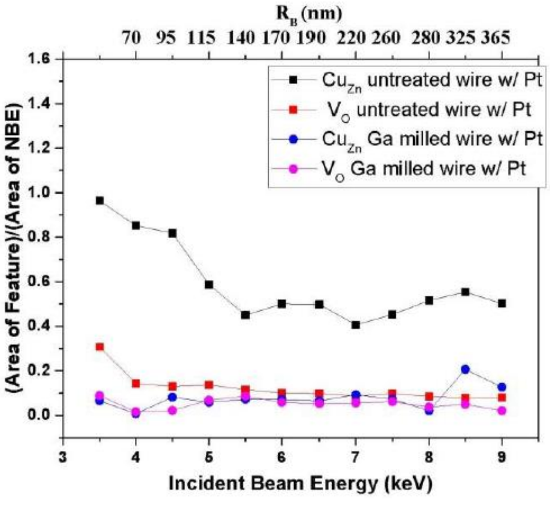

Figure 1: DRCLS Depth profiles of Cu_{Zn} and V_O in Ga-milled versus unmilled nanowire.

The interfacial physics of contacts to NW's is influenced by the diameter of the NW and its defect profile at the interface. Through the control of defects in these NW's by Ga-ion surface modification, Ohmic and Schottky contacts can be fabricated *in-situ* using a single metal. The authors gratefully acknowledge support from National Science Foundation Grant No. DMR-1305193 (Charles Ying and Haiyan Wang).

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