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# Sensitivity of Pt/ZnO Schottky Diode Characteristics to Hydrogen

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ZnO is currently attracting attention for application to UV light-emitters, transparent high power electronics, surface acoustic wave devices, piezoelectric transducers and as a window material for display and solar cells. For some of these applications, it has advantages relative to GaN because of its availability in bulk, single-crystal form and its larger exciton binding energy. There have been many reports of using ZnO for inorganic gas sensing. Numerous mechanisms were suggested including the desorption of adsorbed surface oxygen and grain boundaries in poly-ZnO, exchange of charges between adsorbed gas species and the ZnO surface leading to changes in depletion depth and changes in surface or grain boundary conduction by gas adsorption/desorption.

In this work, we suggest that indiffusion of atomic hydrogen donors, created by catalytic decomposition of adsorbed hydrogen molecules on the Pt Schottky contact, into the near-surface of bulk ZnO is a possible mechanism for changes in current of diode structures. The bulk ZnO crystals from Cermet, Inc. showed electron concentration of $9\times10^{16}$ $cm^{-3}$ and the electron mobility of 200 $cm^2/V\cdot s$. at room temperature from van der Pauw measurements. Ti (200 Å)/Al (800 Å)/Pt (400 Å)/Au (800 Å) were deposited on the back of the bulk ZnO crystals by e-beam evaporation. After the metal deposition, the samples were annealed at 200 °C for 1 min in $N_2$ ambient. The front face was deposited with plasma-enhanced chemical vapor deposited $SiN_X$ at 100 °C and windows opened by wet etching so that a thin (20nm) layer of Pt could be deposited by e-beam evaporation. After final metal of e-beam deposited Ti/Au (300 Å/1200 Å) interconnection contacts was deposited, the devices were bonded to an electrical feed-through and exposed to different gas ambients in an environmental chamber while the diode current-voltage (I-V) characteristics were monitored. Figure 1 shows a schematic (top) and photograph (bottom) of the completed device.

Figure 2 shows the forward current-voltage (I-V) characteristics at 25 °C of the Pt/ZnO diode both in pure $N_2$ and in ambients containing various concentrations of $H_2$. Figure 3 shows the change in forward current for the ZnO diodes at a fixed bias of 0.5V, as a function of the mole fraction of $H_2$ in a $N_2/H_2$ ambient. The current change shows some evidence of saturation behavior at high $H_2$ mole fractions, which suggests the donor concentration begins to be limited, either by the supply or solubility of atomic hydrogen. The Pt/ZnO Schottky diodes showed a collapse of their rectifying I-V characteristics upon introduction of $H_2$ above 50 ppm in a $N_2$ ambient. The introduction of hydrogen shallow donors into the near-surface region of the ZnO is a plausible mechanism for the I-V characteristics at room temperature.

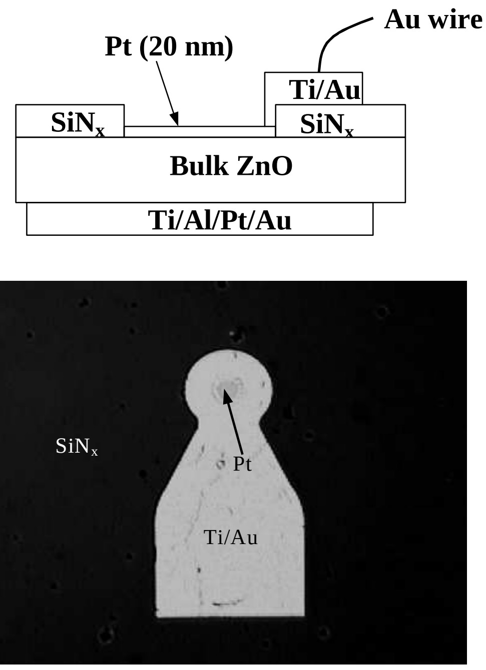


Figure 1. Schematic of bulk ZnO Schottky diode structure (top) and plain view photograph of completed device.

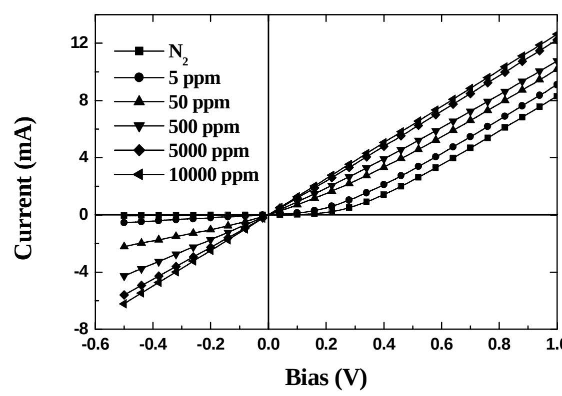


Figure 2. I-V characteristics at 25°C of Pt/ZnO diode measured in different ambients

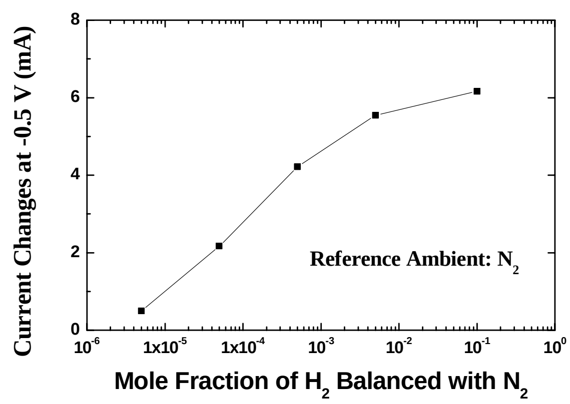


Figure 3. Change in current at a fixed forward bias of 0.5V as a function of mole fraction of $H_2$ in a $N_2/H_2$ ambient.