THE EFFECTS OF CO, WATER VAPOR AND SURFACE TEMPERATURE ON THE CONDUCTIVITY OF A SnO₂ GAS SENSOR

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It is shown that the conductivity of a SnO₂ gas sensor depends on the concentration of CO and H₂O in the atmosphere in which it is placed. The experimental data can be explained in a consistent manner by hypothesizing that 1) adsorbed oxygen depletes the surface electron concentration and therefore decreases the conductivity; 2) adsorbed water causes electrons to accumulate at the surface and therefore increases the conductivity; 3) CO increases the conductivity by removing adsorbed oxygen by reacting with it to form CO₂; and 4) adsorbed water catalyzes the CO to CO₂ reaction.

Key words: tin oxide, gas sensor, oxygen adsorption, carbon monoxide adsorption, water adsorption.

Introduction

It is well known that some gases are adsorbed on the surface of the metal oxide semiconductors, ZnO and SnO₂, (1-4) and that the semiconductors are n-type. They are n-type because they have an excess cation concentration,(1) The adsorbed specie can either decrease the electrical conductivity as it does in the case of oxygen adsorbed on zinc oxide,(1-3,5) or increase the conductivity as it does...
in the case of hydrogen adsorbed on zinc oxide.\(^{(5)}\)

It is thought that oxygen decreases the conductivity because it becomes chemisorbed by capturing donor electrons thereby decreasing the carrier concentration.\(^{(1,5)}\) One piece of evidence which supports this hypothesis is that the oxygen has a greater effect when it is adsorbed on the zinc surface of ZnO (the (0001) surface) where the dangling zinc bonds\(^{(6)}\) more readily give up their valence electrons. Oxygen captures electrons because its work function is greater than the work function of the semiconductor. The captured electrons and the positive depletion layer charge create a potential which bends the energy bands (see Fig. 1)

![Energy Band Diagrams](image)

**Fig. 1** Simple energy band diagrams for a) the surface of an n-type semiconductor in which the surface electron concentration has been depleted by an electron transfer to an adsorbed atom, and b) the surface of an n-type semiconductor in which electrons are attracted to the surface by the preferential alignment of molecular dipoles.