Oxygen ionosorption temperatures on sputtered SnO_2(In) thin films

OXYGEN IONOSORPTION TEMPERATURES ON SPUTTERED SnO_2(In) THIN FILMS

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Abstract: Semiconductor gas sensors base their operation principles on reactions of reducing gas molecules with O_2^- and O^- ions previously adsorbed onto sensor surfaces. Ionosorbed oxygen acts as an electron acceptor trap at the surface of the semiconductor. The reactions between oxygen and reducing gases lower the resistance of the n type semiconductor; therefore it is very important to know the oxygen ionosorption conditions in order to choose proper working temperature of gas semiconductor sensors.

1. Introduction

SnO_2-In doped thin films, studied in this work, have been deposited onto Corning glass substrate by Reactive Magnetron Sputtering from metal targets.Oxygen ionosorption on these films is observed through variations of their electrical conductivity; conductance measurements have been made in a costant flow of inert atmosphere (N_2 or Ar), in synthetic air or in synthetic air containing small concentrations of reducing gases like H_2 and CO.

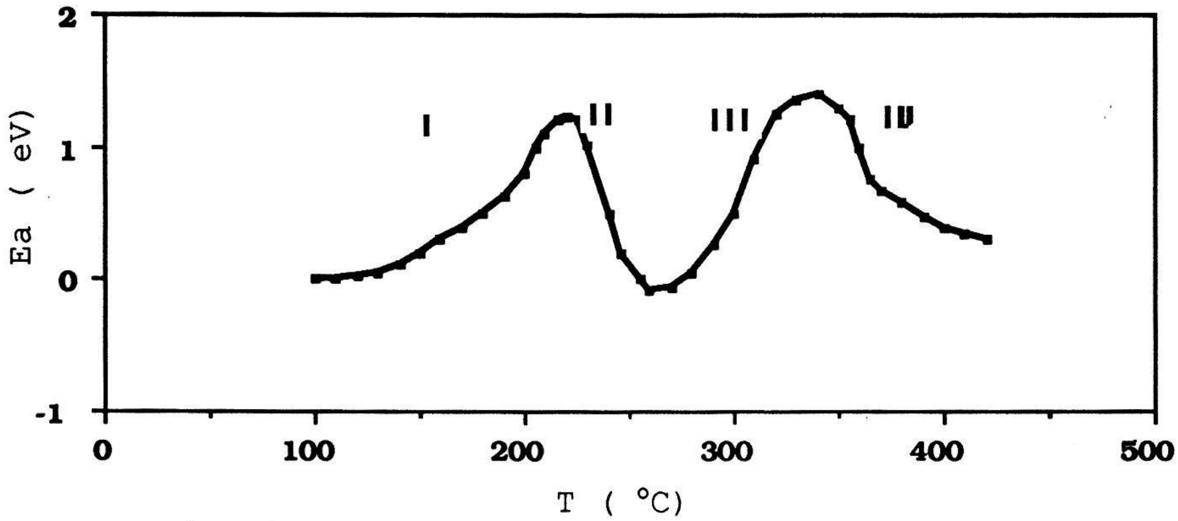
2. Electrical measurements

Arrhenius plot of electrical current vs temperature, obtained with thin film placed in a flow of N_2 or in synthetic air, allows us to determine the state of conductance activation energy vs temperature. The difference between conductance activation energies Ea for thin film placed in N_2 or in synthetic air is plotted in the following figure.We can recognize four zones where Ea increases or decreases versus temperature, they are explained in the following manner:

1st zone (150 °C - 220 °C): Ea increases, O_2 ionosorption is supposed [1];

2nd zone (220 °C - 260 °C):Ea decreases with temperature, this can be explained with desorption of O_2^- according to Weisz limit;

3rd zone (260 °C - 340 °C):as in the first zone, Ea increases with temperature; this fact can be explained as adsorption of new ionic species like O^- or O^{--};
4th zone (> 340 °C): in this zone Ea decreases, desorption of ions adsorbed in the 3rd zone is proposed.



Thin film electrical conductance have been measured for flow isothermal cycles N_2-synthetic air-N_2; adsorption reactions occur in synthetic air atmosphere while desorption reactions occur in N_2 atmosphere, these reactions are faster with increasing temperature. We have always considered equilibrium conditions, measuring conductivity with adsorption and desorption times long enough to obtain steady state conditions. From such conductance variations we have obtained at different temperatures O_i and O_d, which are respectively normalized values for ionosorbed and desorbed oxygen. Two separate desorption peaks exist, caused by ionic species which desorb; according with previons results these species could be O_2^- at low temperatures (T =.260 °C) and O^- or O^{--} at higher temperatures (T >350 °C) [2].

3. Adsorption properties of thin film towards reducing gases

Adsorption isotherms of H_2 and CO, presents in a synthetic air flow at ambient pressure in 100-1000 ppm. concentrations interval, have been studied with conductance measurements in d.c. current. We observe an high sensivity, especially towards H_2 chemisorption, around $O^-(O^{--})$ ion desorption temperature; such sensivity results from reducing gases reactions with O^- or O^{--} ions, while a reaction with O_2^- ion is nearly negligible [2].

4. References

[1] S. C. Chang, J. Vac. Sci. Technol. 17-1, 366 (1980)
[2] G. Sberveglieri et. al, Proc. Eurosensor II, Enschede, The Netherlands, Nov. 1988, p.135