ZnO BASED NONLINEAR CERSEMS

by

BHARAT BUSHAN
DEPARTMENT OF PHYSICS

Thesis submitted
in fulfilment of the requirements
of the degree of

DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

AUGUST, 1982

Thesis Supervisc

Professor K.L. Chopra
Thin Film-Solid State Technology Cell
Department of Physics
Indian Institute of Technology, Delhi
New Delhi-110016, India

Dr. S.C. Kashyap
Centre for Material Science and Technology
Indian Institute of Technology, Delhi
New Delhi-110016, India

ACKNOWLEDGEMENTS

I am deeply grateful to Professor K.L. Chopra and Dr. S.C. Kashyap for their inspiring guidance and active involvement in all phases of this work. My sincere thanks are due to Dr. D.K. Pandya for many stimulating discussions during the compilation of this manuscript.

It was a great privilege to be a member of the Thin Film Group. The unstinted cooperation extended by all my colleagues, especially Dr. S. Rajagopalan, Mr. R.C. Budhani, Mr. K. Solomon Harshavardhan and Mr. M.P. Singh is gratefully acknowledged. Interactions with them have always been stimulating and exciting. I am indebted to Dr. V. Dutta for his continued interest in my work.

It is indeed a pleasure to thank Mr. P. Palvannan and Miss A. Rajvanshi for their active involvement in this research project. Thanks are also due to Miss C.S. Uma Rani for reading the manuscript and making necessary corrections.

I am extremely thankful to Mr. Lal for his help in scanning electron microscopy.

The financial support extended by IIT Delhi is gratefully acknowledged.

I thank Mr. N.S. Gupta for his efficient drafting work. Finally, it is a pleasure to thank Mr. V.N. Sharma for his efficient typing of the manuscript.

Bharat Bhushan

(BHARAT BHUSHAN)

ABSTRACT

Microstructural, compositional, electrical, electronic and dielectric properties of ZnO based ceramic semiconductors (cersems) have been investigated by employing various techniques such as scanning electron microscopy, Auger electron spectroscopy, I-V characteristics, response time, Hall measurements, capacitance-voltage measurements, dielectric measurements and voltage contrast secondary electron microscopy.

Effect of a large number of additives/impurities such as Bi_2O_3, Sb_2O_3, PbO, CoO, In_2O_3, BaO etc. on sintering kinetics and microstructure of ZnO have been investigated. A two phase microstructure in which ZnO grains are enveloped in thin layers (< 50 Å) of segregated additives is essential for observing a nonlinear behaviour in I-V characteristics. A liquid phase sintering in Bi_2O_3 gives rise to such a two phase microstructure and hence initiates nonlinear behaviour. Devices with high nonlinearity are extremely useful in electrical, electronic and communication industries. By employing a simultaneous addition of two to four additives various device parameters can be adjusted to a desired value. Explicit role of various additives in modifying device parameters like resistivity, nonlinearity parameter, breakdown voltage, power handling capacity and device capacitance have been established. Devices with varied voltages (20 volts to few kilovolts) and wattages (1 watt/cm^2 to 10 watt/cm^2) have been fabricated.

Effect of sintering temperature, sintering time and composition on the dielectric parameters of the cersems have been investigated. Variation of dielectric parameters with frequency and measurement temperature have been carried out. High dielectric constant of the cersems has been explained on the basis of depletion layers existing at grain-intergranular interface and extending into ZnO grains. The nonlinear behaviour also arises because of these depletion layers which give rise to potential barriers. High dielectric constant, temperature dependence of I-V characteristics and capacitance voltage measurements support the presence of grain boundary barriers. The potential barriers have been revealed directly by employing voltage contrast secondary electron microscopy. Breakdown occurs by tunnelling of carriers through these barriers at high applied fields.

The present study reveals that the electrical and dielectric properties of ZnO cersems are governed by their microstructure. Either highly conducting (degenerate) or highly insulating (linear/nonlinear) cersems can be developed by controlling the microstructure.

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