

Correlation Between Electron Beam Evaporation Conditions and Sensor Response of Cerium Oxide Coatings

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INTRODUCTION

Cerium oxide (ceria) has drawn significant attention due to its exceptional oxygen storage capacity and high redox potential, allowing for applications in solid oxide fuel cells¹, catalysis², and sensing³. While the influence of process parameters on the properties of ceria thin films deposited by various PVD methods has been of certain interest, reports on the influence of electron beam evaporation (EBE) conditions on the properties of ceria coatings are scarce. This work aimed to study the influence of electron beam deposition (EBE) parameters on the morphology, microstructure, and optical properties of cerium oxide thin films. Furthermore, gas sensing measurements of the prepared CeO₂ thin films with Pd catalyst were correlated with the structural properties of ceria layer, providing insight into potential applications of the CeO₂ thin film coatings with tailored properties.

EXPERIMENTAL/THEORETICAL STUDY

Cerium oxide thin films were prepared in three EBE processes: 1) with no modifications, 2) using substrate heating to 200 °C during deposition, and 3) using ion beam assistance. The properties of the coatings were studied using XRD, Raman spectroscopy, SEM, AFM, and UV-Vis spectroscopy. The gas-sensing properties of the thin film structures toward hydrogen, ethanol, ammonia, and benzene were determined based on the measurements of resistance changes at an operating temperature of 200 °C.

RESULTS AND DISCUSSION

The coatings deposited in standard process and with substrate heating were smooth and densely packed, while the use of ion beam assistance resulted in the formation of fibrous structure with triangular grains and rough surface. The GIXRD studies revealed an amorphous structure with contributions of cubic CeO₂ nanocrystalline phase with preferred (111) orientation. In the Raman spectra, blue shift and significant broadening of the F_{2g} peak indicated a high contribution of amorphous phase and structural defects in the ceria coatings.

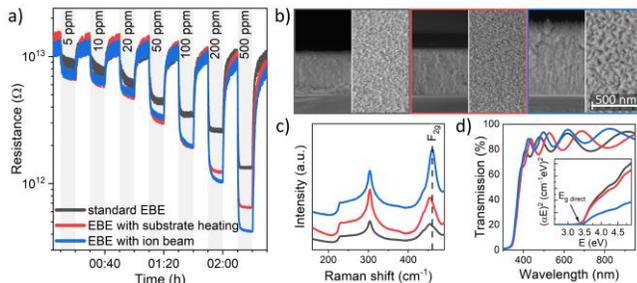


Fig. 1 Sensing response to ethanol (a), SEM images (b), Raman spectra (c), and optical transmission spectra (d) of ceria thin films.

All three sensing structures exhibited excellent response/recovery kinetics. The highest sensor response and high selectivity to ethanol were obtained for the ceria thin films prepared in the EBE process with ion beam assistance.

CONCLUSION

Ceria thin film structures were prepared by electron beam evaporation in three deposition processes, resulting in different morphology and structural properties. The potential application of cerium oxide thin films in gas sensing was assessed by preparing Pd/CeO_x structures and measuring the electrical response to various gases.

REFERENCES

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